Eastern Research Group, Inc.

# Barge Emission Estimates

## Final Report

**Prepared for:**

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**Air Quality Division**
**The Texas Commission on Environmental Quality**

**Prepared by:**

**Eastern Research Group, Inc.**

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## Acronyms

| | |
|---|---|
| AIS | Automatic Information Systems |
| API | American Petroleum Institute |
| ATB | Articulated Tug/Barges |
| AWO | American Waterway Operators |
| BBL | Barrel |
| BMP | Best Management Practices |
| BPA | Beaumont/Port Arthur |
| CC | Corpus Christi |
| EIIP | Emissions Inventory Improvement Program |
| EIS CER | Emissions Inventory System Consolidated Emissions Reporting |
| EPA | Environmental Protection Agency |
| ERG | Eastern Research Group |
| ETBE | Ethyl Tert-Butyl Ether |
| EtOH | Ethanol |
| GIS | Geographic Information System |
| HAP | Hazardous Air Pollutant |
| HGB | Houston-Galveston-Brazoria |
| HRVOC | Highly Reactive Volatile Organic Compound |
| ICW | Intra-Coastal Waterway |
| ITB | Integrated Tug/Barges |
| LASH | Lighter Aboard Ship |
| LDEQ | Louisiana Department of Environmental Quality |
| MEK | Methyl Ethyl Ketone |
| MIBK | Methyl Isobutyl Ketone |
| MSDS | Material Safety Data Sheet |
| MTBE | Methyl Tert-Butyl Ether |
| MW | Molecular Weight |
| NEC | Not Elsewhere Classified |
| NIF3.0 | National Emissions Inventory Format version 3.0 |
| OPA-90 | Oil Pollution Act of 1990 |
| PSI | Pounds Per Square Inch |
| QA | Quality Assurance |
| RVP | Reid Vapor Pressure |
| SCC | Source Classification Code |
| TAME | Tertiary Amyl Methyl Ether |
| TCEQ | Texas Commission on Environmental Quality |
| TexAER | Texas Air Emissions Repository |
| TWOA | Texas Waterway Operators Association |
| VOC | Volatile Organic Compound |
| VP | Vapor Pressure |
| VTS | Vessel Traffic Service |
| WCUS | Waterborne Commerce of the United States |

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Key technical input for this study was provided by industry representatives from the American Waterway Operators (AWO) and the Texas Waterway Operators Association (TWOA). Mr. Mark Wright, Vice President of the AWO Southern Region, and Mr. Morgan Johnson, TWOA Environmental Committee Chair, were particularly helpful in providing information regarding barge operating practices, product characteristics, and emission estimation methods.

# 1.0 Executive Summary

The purpose of this study is to locate and quantify volatile organic compound (VOC) emissions from liquid cargo barges while in transit in the Houston-Galveston-Brazoria (HGB), Beaumont/Port Arthur (BPA), and Corpus Christi industrial waterways for the 2008 calendar year. The study identified and determined key factors needed to estimate in-transit emissions, including the number of barges, barge capacities, typical cargo, barge color, and transit time. VOC as well as speciated hazardous air pollutant (HAP) and highly reactive VOC (HRVOC) emissions were estimated at the county level.

At the outset of the study, an assessment was performed to identify key factors influencing barge transit emissions, including available estimation methodologies and data sources. The information collected was used to develop a recommended emission inventory methodology. Based on the review, the following data inputs were identified as useful for quantifying barge transit emissions:

- Product volumes by county/region, disaggregated by type to the extent possible;
- Product characteristics (vapor pressure vs. temperature, density);
- Ambient conditions by region and season (water and air temperatures, solar insolation);
- Barge trip counts and transit times;
- Distribution of loaded vs. empty trips;
- County level Geographic Information System (GIS) data to spatially allocate barge route data;
- Barge characteristic profiles, including:
  - Color
  - Vapor space volume, loaded and empty (with heel)
  - Tank configurations (volume/surface area/hull specifications)
  - Pressure valve specification and frequency
  - Product temperature

Several sources of data were identified for the above modeling inputs. First, high quality barge activity data was obtained from the U.S. Coast Guard detailing vessel movement data through the Vessel Traffic Service (VTS) in the HGB and BPA areas.[1] This data allows for the determination of barge counts, transit times, and spatial and temporal allocation. Product volume and type data was obtained from the U.S. Corps of Engineer's Waterborne Commerce of the United States (WCUS) data, which tracks domestic barge shipments for transportation tax

[1] Although VTS data was not available for the Corpus Christi area, simple barge trip counts were obtained from the Port of Corpus Christi for evaluation.

purposes. The WCUS provides product tonnage by category, such as gasoline, diesel, crude, alcohols, benzene, toluene, and other chemicals.

Industry stakeholders were identified to assist in determining the additional product distribution and barge characteristic profile information required to develop the barge inventory. Industry representatives from the American Waterway Operators (AWO) and the Texas Waterway Operators Association (TWOA) agreed to provide key information and peer review assistance for this study. The AWO is the national trade association representing the owners and operators of tugboats, towboats, and barges serving the waterborne commerce of the United States.[2] The TWOA represents 27 member companies, all owners and operators of marine equipment in Texas.[3]

Based on the review of available calculation methods, available data, and industry representative input, a four-step process was developed for estimating barge transit emissions for the study areas.

1. *Identify ultra-low volatility and non-volatile product categories for exclusion.* Certain products carried by tank barges have essentially negligible vapor pressures, even under summertime high temperature conditions. As such, these products will not generate significant VOC emissions, regardless of barge pressure ratings.

2. *Use API Bulletin 2516 "Evaporation Loss from Low-Pressure Tanks" to identify which products/barge pressure rating combinations will not result in breathing loss emissions.* The API emission loss equation was used to determine the incremental increase in vapor space pressures considering the full range of anticipated product vapor pressures and temperature ranges for different months and locations. The results of these calculations determine the minimum vent pressure settings needed to prevent breathing losses for a particular product.

3. *Apply EPA's TANKS model equations to determine emission rates for all remaining product/barge psi combinations.* Emission factors were then estimated for all product types predicted to exceed barge pressure rating thresholds for some portion of anticipated operating conditions, using the EPA's TANKS model equations.[4] Emission factors were expressed in terms of product volume transported per unit time.

4. *Combine product volume estimates with emission factors to obtain VOC and HAP/HRVOC emission estimates.* WCUS product volumes were first allocated across different product types and then allocated to different barge pressure ratings. Product volumes were then further allocated across month and trip length bin, for

[2] The American Waterways Operators, http://www.americanwaterways.com/about_awo/index.html
[3] Texas Waterway Operators Association, http://www.twoa.org/index.htm
[4] EPA's TANKS model is designed to estimate emissions from stationary above ground storage tanks operating at atmospheric pressure.

combination with the emission factors generated using the TANKS equations. VOC mass emission estimates were speciated to obtain HAP and HRVOC estimates, and finally allocated spatially to obtain county-level totals.[5]

The API calculation method for low pressure tanks was used as a screening tool to determine which product type/barge psi rating combinations were not expected to have transit VOC emissions under normal operating conditions. Based on this analysis it was concluded that properly operated 3 psi and 6 psi barges would not release VOC emissions.

Accordingly, emission factors were developed only for 1 psi barges using the TANKS model equations. As air temperature and solar insolation are the primary drivers for the TANKS equations, emissions were modeled for each month and each region separately to account for differences in these data inputs.

A spreadsheet was developed to calculate the VOC emission factors associated with each scenario combination. These factors are dependent upon trip duration and study region, and therefore should not be applied for all transport scenarios. The resulting emission factors were then combined with the activity data to estimate total VOC emissions by product type, trip length category, barge psi rating, month, and county. These totals were then summed to provide annual VOC emissions by county. Speciated emissions for the identified HAP and HRVOC species were also developed for each product type using appropriate speciation profiles obtained from U.S. EPA's *SPECIATE* database and representative material safety data sheets (MSDS).

Resulting emissions and activity data were reported for each Source Classification Code (SCC) proposed for this study in NIF3.0 format, suitable for loading into the Texas Air Emission Repository (TexAER).

Table ES-1 presents the 2008 annual VOC emission estimates for barge transit activity, by product and study region.

[5] Note that HRVOC emissions are a result of trace concentrations contained in mixtures of volatile liquid cargos, and do not represent direct emissions associated with HRVOC transport itself.

**Table ES-1. Annual VOC Barge Transit Emissions by Product Type and Study Region, Base Case 2008 (Tons/Year)**

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| Acyclic Hydrocarbons | heptanes | 0.2967 | 0.0382 | 0.0873 |
| | n-decane | 0.0519 | 0.0000 | 0.0221 |
| | 1-heptene | 0.3212 | 0.0419 | 0.0915 |
| | hexane | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.1050 | 0.0000 | 0.0484 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.3261 | 0.0319 | 0.0296 |
| | isopropanol | 0.2972 | 0.0253 | 0.0288 |
| | butanols (iso butyl alcohol) | 0.2667 | 0.0076 | 0.0337 |
| | decanol | 0.0003 | 0.0000 | 0.0000 |
| | hexanol | 0.0651 | 0.0000 | 0.0100 |
| | 2-ethylhexanol | 0.0131 | 0.0000 | 0.0021 |
| Benzene/Toluene | benzene | 1.5409 | 0.2183 | 0.2601 |
| | toluene | 1.1523 | 0.0739 | 0.2616 |
| Carboxylic Acids | acetic acid | 0.1749 | 0.0036 | 0.0205 |
| | propionic acid | 0.0540 | 0.0000 | 0.0074 |
| | butyric acid | 0.0183 | 0.0000 | 0.0026 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.9372 | 0.0000 | 0.6110 |
| | #2 diesel | 0.1493 | 0.0000 | 0.1006 |
| | marine diesel oil | 0.1493 | 0.0000 | 0.1006 |
| Gasoline | HGB Summer Gasoline | 8.9248 | 0.0000 | 0.0000 |
| | HGB Winter Gasoline | 4.9254 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline | 0.0000 | 2.8158 | 0.0000 |
| | BPA Winter Gasoline | 0.0000 | 2.3870 | 0.0000 |
| | Corpus Summer Gasoline | 0.0000 | 0.0000 | 6.8404 |
| | Corpus Winter Gasoline | 0.0000 | 0.0000 | 4.2200 |
| Kerosene | kerosene (fuel oil #1) | 0.0047 | 0.0000 | 0.0015 |
| | jet kerosene (Jet A) | 0.0010 | 0.0000 | 0.0003 |
| | jet naphtha (JP-4) | 0.0291 | 0.0039 | 0.0057 |
| Naphtha and Solvents | naphtha | 1.1796 | 0.0000 | 0.5342 |
| | solvents (JP-4) | 3.9004 | 1.0273 | 1.0352 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | styrene | 0.2231 | 0.0007 | 0.1502 |
| | cumene | 0.1648 | 0.0005 | 0.1130 |
| | MEK | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 |
| | butyl acrylate | 0.2027 | 0.0002 | 0.1385 |
| | vinyl acetate | 0.0000 | 0.0000 | 0.0000 |

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| | xylene | 0.2766 | 0.0053 | 0.1769 |
| | propyl acetate | 0.3609 | 0.0338 | 0.1857 |
| | MIBK | 0.2473 | 0.0041 | 0.1581 |
| Petroleum Products NEC | lube oil | 0.0021 | 0.0000 | 0.0007 |
| Residual Fuel Oil | No. 6 fuel oil | 0.0044 | 0.0000 | 0.0025 |
| | ***Total*** | ***26.3665*** | ***6.7195*** | ***15.2807*** |

When comparing emission totals across regions, the emission totals for the HGB area are surprisingly low compared to the Corpus Christi area. This is largely due to the preponderance of relatively short trips (with minimal heating) that occur in the HGB region compared to Corpus Christi. It is also noteworthy that the vast majority of emissions (> 95%) result from empty barge movements, due to the much greater vapor space volumes subjected to heating and pressure increases, compared to loaded barges.

A number of uncertainties were identified associated with the data inputs and emission calculation methods, and are discussed in detail in this report. While the net effect of these uncertainties is unknown, sensitivity analyses were conducted to estimate the relative importance of several of these factors on mass emissions estimates. First, uncontrolled emissions were estimated by assigning 100 percent of all products to 1 psi barges. The results indicate an approximately 83 percent control effectiveness for barge transit VOC emissions.

Additional analyses were performed in order to evaluate the sensitivity of emission estimates to trip length and solar absorptance. The findings of each case are discussed in detail.

While this study quantified barge transit emission estimates, it did not consider emissions from other related activities. Specifically, emissions associated with barge loading and unloading operations are generally controlled at dockside facilities, and residual emissions are already included in point source emissions estimates. In addition, emissions from tanker transfers (lightering) and barge-to-barge product transfers were also excluded from analysis.

## 2.0 Introduction

The purpose of this study is to locate and quantify volatile organic compound (VOC) emissions from liquid cargo barges while in transit in the Houston-Galveston-Brazoria (HGB), Beaumont/Port Arthur (BPA), and Corpus Christi industrial waterways. These include ship channels, bays, inter-coastal waterways, and off-shore areas within nine nautical miles of the coast. The project identified and determined key factors needed to estimate in-transit emissions, including the number of barges, barge capacities, typical cargo, barge color, and transit time. This information was used to estimate the total barge emissions in these three geographical areas for the 2008 calendar year. VOC, as well as speciated hazardous air pollutant (HAP) and highly reactive VOC (HRVOC) emissions were estimated at the county level.

Barge transits are quite common in the study areas, totaling tens of thousands of individual barge trips per year. In addition, much of the liquid product carried by these barges is volatile, having the potential to generate VOC emissions. However, due to a lack of key estimation parameters and appropriate emissions modeling procedures, a portion of the barge transit emissions for the state of Texas have been unreported or underreported prior to this study. Accordingly, this study provides improved emissions estimates for this source category, which can in turn be used for preliminary assessments of ozone formation and toxic exposure impacts in the future. In addition, the study provides estimates regarding the effectiveness of existing emission controls, and a starting point for guiding future research priorities for this source category.

While this study quantified barge transit emission estimates, it does not consider emissions from other related activities. Specifically, emissions associated with barge loading and unloading operations are generally controlled at dockside facilities, and residual emissions are already included in point source emissions estimates. In addition, emissions from tanker transfers (lightering) and barge-to-barge product transfers are also excluded from analysis, as discussed in the following section.

# 3.0 Background

## 3.1 Tank Barge Overview

The term "barge" can refer to any flat bottomed marine vessel that is intended for shallow water travel on inland waterways. Barges come in a broad range of types including self-propelled, sailing barges, very small barges used for dock construction, and even ocean-going barges as large as a football field. This study is concerned with barges that carry liquids, known as "marine tank barges", since these may transport volatile products with associated VOC emissions. Marine tank barges vary in size, as defined by their product volume capacity, ranging from a few hundred barrels to over a million barrels.

**Figure 3-1. Inland Tank Barges (5)**

General tank barge size categories are described below:

- *Small marine tank barges:* Include Lighter Aboard Ship (LASH) barges and other small barges typically used for refueling ships, dredges, or other marine vessels;
- *Medium sized barges:* The most common in the inland waters of Texas, with capacities between 10,000 and 30,000 barrels, usually associated with terminal to

terminal product deliveries. Typical dimensions are 12 feet high, 35 to 50 feet wide, and 200 to 300 feet long;

- *Jumbo barges:* An industry term describing inland, medium-sized barges greater than 30,000 barrels but usually less than 75,000 barrels, typically with widened or lengthened configurations;
- *Super-sized barges:* Usually ocean-going with capacities ranging from several hundred thousand to over a million barrels, including:
  - Line haul barges pulled behind a tugboat on a steel cable,
  - Articulated tug/barges (ATB), which are large pushboats (tugs capable of pushing barges from the stern using a special coupling), and
  - Integrated tug/barges (ITB) similar to true ships, but actually comprised of a tugboat that fits into a notch in the stern of the barge, rarely separated except at a shipyard.

Jumbo and super-sized barges are not as common in Texas waters relative to conventional, medium sized barges, but can have a disproportionate impact on volumes, activity, and resulting VOC emissions. Some of these barges may be used in offshore "lightering" operations involving transfers of crude oil between a large tanker ship and an ocean-going barge; as required by Coast Guard regulations, lightering is conducted about 60 miles out to sea and any associated emissions are therefore outside the geographic area of this study, which is limited to state waters (9 nautical miles, or 10.4 statute miles).

As in railroad operations, there are towboat and barge activities that function like switchyard operations (also known as fleeting), or longer-range travel (sometimes referred to as line haul). Barge activity can be further subdivided into several categories, as described below:

- *Fleeting:* Storing loaded or empty barges, positioning them for line haul service. There are about 400 tugboats in the barge industry in Texas and approximately 1,200 barges, which require frequent repositioning when customers send new orders for deliveries.
- *Short-Line Service:* Similar to railroads, some tug/barge activity is involved in short trips within a port area, such as refinery-to-chemical industry service. Often referred to informally as a "taxi" service.
- *Inland Line Haul:* Trips that may range from the Mississippi River to Corpus Christi and Brownsville, picking up barges or mooring them as they proceed down the waterway. These tug/barge movements usually involve longer trips on the Intra-Coastal Waterway (ICW).[6]
- *Ocean Line Haul:* Involving large tugs and barges that carry loads from port to port by way of the ocean. Deliveries can be as far away as Mexico, Puerto Rico, and New York.

[6] Mississippi service is often referred to as Inland River Service.

When a barge is grounded or somehow damaged, other barges may be used to transfer some (lightering) or all (emergency response) of the onboard product, and VOCs may be emitted during such transfers. However, such practices are believed to be very infrequent by industry representatives. In addition, no specific information was identified in the literature or in discussion with industry stakeholders regarding the number and frequency of such events. As such, emissions associated with barge-to-barge transfers were excluded from this analysis. This exclusion is consistent with the general study approach, intended to quantify barge emissions under typical operating procedures.

Marine tank barges are usually constructed in a very simple rectangular, box-like configuration using steel with an angled bow to reduce wave action and to provide a "crash zone". While ocean-going barges have at least one anchor located on the bow, the inland barges that are the primary target of this study do not have anchors. The sides and bottom of a barge are typically constructed with half-inch thickness steel, with heavier, three-quarter inch steel on the deck, and steel beams used as reinforcements. Prior to the mid-1980s, most barges were single-hulled, meaning there was a single layer of steel plating on the sides and bottom. However, during this time period several barge failures occurred that resulted in product spills near Galveston, Texas. In conjunction with the Oil Pollution Act of 1990 (OPA-90), new or reconstructed liquid marine barges were required to adopt double-hull construction, meaning there are two layers of steel plating with a gap of roughly two feet or more, depending on size.[7] These regulations also required periodic hull inspections by a certified engineer as well as U.S. Coast Guard safety inspections. Approximately 80 percent of the current inland marine tank barge fleet is thought to be double-hulled.

There are many potential VOC release points on the deck of a barge, including loading hatches, access hatches, and openings that are used for ventilating the tank. A typical inland, medium-sized tank barge has six tank compartments. A manifold system of complex piping is used to fill and empty a barge while allowing for air exchange. The exchange of air is controlled in the following ways:

- *Loading:* During barge loading, liquid product is transferred into the barge using electric pumps located on the landside. The pumping causes vapor laden air inside the barge to escape, so for products with volatile cargos, a return line is routed from the barge vent stack to a flare or condenser at the marine terminal. Barge loading is not evaluated in this study since it is generally included in landside facility point source emissions estimates, although emission estimates

[7] This air gap on the sides and bottom of a barge have important implications for this study, since it can affect the thermal exchange rate with the surrounding air and water, as discussed below.

obtained from the Texas Air Emissions Repository (TexAER) for SCC 2505020000 are summarized in Table 3-1. (6)

- *Transiting:* The act of moving a barge from one location to another, during which diurnal heating may cause the vapors in the headspace of the tank to expand and be released. Transit emissions are the focus of this project. During normal transits of a loaded barge, about 97 percent of the tank is filled with product. During transits of an empty barge, the cargo volume is assumed to be completely filled with air, except for some small residual amount of liquid that collects in sump wells used for filling and emptying the product. Pressure valves assist with controlling breathing losses associated with vapor space expansion, as described in detail below.
- *Unloading:* When unloading product from most inland marine tank barges, diesel-powered pumps located near the bow are used to push the product to the landside terminal racks. Product unloading should not generate VOC emissions from a barge, with the rare exception of spills, since a vacuum is drawn onboard when the product is pumped to the terminal or ship, and fresh air enters the tank compartments.[8]

**Table 3-1. Barge Loading/Unloading VOC Emissions by County, 2008 (6)**

| County | Annual (Tons/Year) | OSD (Tons/Day) |
|---|---|---|
| Aransas | 0.11 | 0.0003 |
| Brazoria | 2,559.45 | 7.0122 |
| Calhoun | 223.20 | 0.6115 |
| Cameron | 318.93 | 0.8738 |
| Galveston | 0.00 | 0.0000 |
| Harris | 2,443.65 | 6.6949 |
| Jefferson | 0.00 | 0.0000 |
| Matagorda | 6.57 | 0.0180 |
| Nueces | 0.00 | 0.0000 |
| Orange | 160.35 | 0.4393 |
| Victoria | 5.10 | 0.0140 |
| Willacy | 19.48 | 0.0534 |
| **Total** | **5,736.84** | **15.7174** |

To help control VOC emissions, barges have low pressure valves which prevent vapor space air from leaking up to the valve's rated pressure. Under normal operating conditions these pressure valves contain essentially all of the product vapors in the tank. However, under certain conditions some vapors may leak, as discussed in Section 4 below. Barge pressure valves are rated as follows:

- *1 pound per square inch (1 psi):* Commonly used in inland marine tank service for petroleum and chemical products with relatively low vapor pressures.

[8] There are valves to control this incoming air, though this component is not discussed in detail in this report.

- *3 psi:* Less common, but still frequently seen in inland service, these barges are used for higher volatility products.
- *6 psi:* Relatively rare, used for the most volatile products.

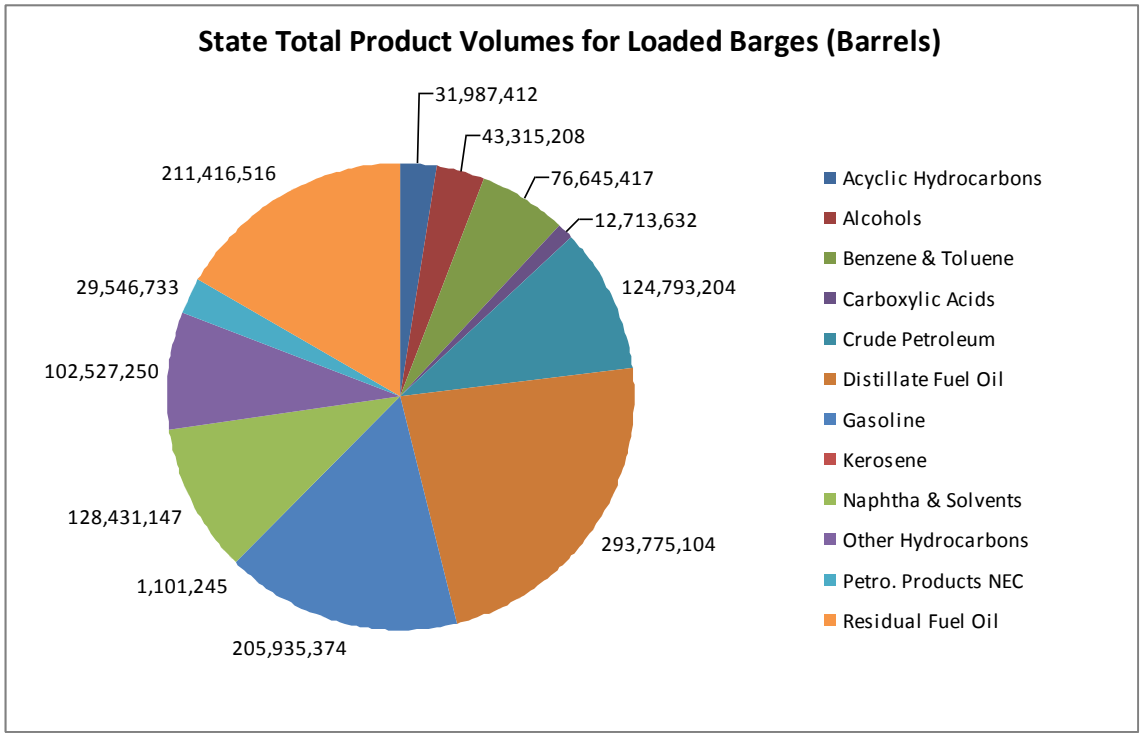
The relationship between product volatility, operating conditions, barge pressure valve ratings, and VOC emissions will be discussed further in Sections 3.3 and 4.

## 3.2 Tank Barge Product Types

Tank barges carry a wide variety of fluid products. Certain products such as butadiene, butylenes and ethylene, which are gaseous at normal atmospheric conditions, are transported in high pressure barges that maintain pressures substantially higher than those used for the typical barges noted above (e.g., 100 psi). (7) This project assumes that high pressure barges are effective at maintaining their internal pressures and minimizing product loss.

A wide range of liquid products are transported via barge, including petroleum products as well as a variety of feedstock for the petrochemical and other industries. Figure 3-2 below presents a breakdown of liquid product categories transported by barge in Texas in 2008, based on the Waterborne Commerce of the United States (WCUS) data, from the U.S. Army Corps of Engineers. Some of these products (for example, inorganic compounds such as molten sulfur), are non-volatile, with no associated VOC emissions. Accordingly, this study is limited to evaluating VOC emissions associated with volatile liquid products such as gasoline and crude oil. Specific data regarding product types and volumes is provided in Section 4.

**Figure 3-2. Tank Barge Product Volumes for Texas, 2008**




## 3.3 Barge Transit Emissions

When a volatile liquid is loaded into a barge, approximately three percent of the storage volume is unused, with the remaining vapor space filled with ambient air. As time goes by, a small fraction of the liquid will evaporate into the vapor space, increasing the pressure of the air/vapor mixture. Assuming the gas in the vapor space is not allowed to expand or escape, the vapor level in the air will approach its saturation point, and an equilibrium vapor concentration will be reached (for a given temperature and containment pressure). Due to the relatively small vapor space available in a loaded barge, we would expect saturation levels to be approached relatively quickly for volatile products.

The partial pressure of the product vapor, combined with the pressure of the air in the vapor space, will increase pressures in the vapor space above atmospheric (14.7 psi) by some amount, depending upon the volatility of the specific product. If the liquid surface temperatures increase, more product will volatilize into the vapor space, increasing vapor pressures inside the barge further. In most instances, the pressure increase due to product volatilization is relatively small. However, heating of the vapor space itself (e.g., due to solar radiation on the barge deck) can also cause a substantial increase in vapor pressure. Due to these factors, the pressure in the

vapor space can exceed the barge pressure ratings under some conditions, causing vapor-laden air to vent to the atmosphere.

For a well-maintained and properly operated barge, this venting (also termed breathing loss) is anticipated to be the principal cause of VOC emissions during barge transits. Given the importance of vapor space heating to this process, barges are not expected to experience significant breathing losses during night-time operation, when vapor space temperatures and pressures are normally falling over time.

Once a barge is unloaded, it may make one or more trips before its next loading event. The vapor space in an empty barge, although not saturated, still contains some amount of product vapor which could be emitted through breathing losses. In addition, because the vapor space in an empty barge is much larger than in a loaded barge (100 percent of the cargo volume, compared to 3 percent for a loaded barge), thermal heating of the vapor space will have a much greater impact on internal vapor pressure. Given these factors, detailed assessments are needed regarding breathing losses for both loaded and unloaded barges.

Based on these factors, it is clear that breathing losses are possible during barge transits, especially for high volatility products during summer months, when vapor space heating will be at its highest. However, breathing losses can be minimized or even eliminated by using barges with sufficiently high pressure ratings, even for highly volatile liquid cargos. Barge operators have their own incentives for minimizing product loss. Controlling emissions in transit ensures their customers receive a full cargo, helps avoid exposing employees to potentially harmful vapors, and makes for safer operations. The barge operator industry has promoted a set of best management practices (BMPs), beginning in 2007. Although their emission benefits are not quantified, the BMPs are considered to be effective and are included in the TCEQ's "weight of evidence" demonstration in the HGB area State Implementation Plan (SIP). (8)

# 4.0 Review of Potential Emission Estimation Methodologies

At the outset of the study, an assessment was performed to identify key factors influencing barge transit emissions, including available estimation methodologies and data sources. The information collected during this task was used to develop a recommended emission inventory methodology for review by the TCEQ.

## 4.1 Literature and Model Review

As discussed above, VOC breathing losses during barge transit result from vapor space pressure changes, which are primarily caused by changes in temperature. Specific emission rates will vary depending upon a number of factors, including the types and amounts of products transported, their liquid vapor pressures, and barge pressure ratings. In order to identify key factors influencing emission rates, a review of available studies and barge emission estimation methods was performed. The review began by evaluating the standard emission estimation procedure developed by the U.S. EPA for tank barge transit activities, as presented in the Emission Inventory Improvement Program (EIIP). (9) Emission factors found in the EIIP reflect AP-42 tables for product density, breathing losses for transits, and other determinants. The methodology relies heavily on U.S. Army Corps of Engineers activity data and emission factors (Table 12.4-5 of the EIIP guidance) expressed in terms of pounds of VOC per 1,000 gallons of product transported per week. For example, gasoline transit breathing losses are estimated at 2.7 pounds per 1,000 gallons of gasoline transported per week. These factors represent average, uncontrolled emissions that can be further refined by using control efficiency factors (CE).

The EIIP method has some significant limitations. First, the EIIP guidance tables address only petroleum liquids, omitting other sources of VOCs such as organic chemicals. Second, the EIIP guidance groups all petroleum liquids into five broad groupings (crude oil, distillate oil, residual oil, gasoline, and jet naptha), adding potential uncertainty to emission rates and toxics speciation. Finally, the EIIP emission factor equation takes into account gallons of liquid transported, time in transit, and product-specific constants but does not account for variables such as ambient temperature and vapor space volumes that could potentially have a large impact on emissions.

For these reasons an alternative emissions estimation approach using EPA's TANKS model (version 4.09d) was also evaluated. (10) This model is used to estimate evaporative emissions from stationary above ground storage tanks, typically used in the petroleum and petrochemical industries. The model provides the user with a variety of variables for modeling specific liquids and storage conditions, including ambient temperatures, tank color, vapor space

volume, and tank configurations and controls. Although stationary tanks have some fundamental differences from tank barges (e.g., thermal exchanges with both water and air, configuration differences, possible agitation during transit, etc.), it was concluded that the TANKS model equations could be used with slight modifications to provide a reasonable tool for estimating tank barge transit emissions. Such an approach would require a greater number of model inputs than the EIIP methodology, including barge color, liquid temperatures and volumes, and vapor space temperatures and volumes.

The TANKS model does have one key limitation. Appendix D in the "User's Guide to TANKS" states that the TANKS model uses equations developed under atmospheric conditions and is not equipped to estimate emissions from low-pressure tanks. The User's Guide recommends using API Bulletin 2516 "Evaporation Loss from Low-Pressure Tanks" to determine if the vent pressure settings are sufficient to prevent standing storage losses. (11) As discussed in Section 5, the API methodology can be combined with the TANKS model equations to provide an even more accurate assessment of barge transit emissions than either method alone.

Two recent studies investigating transit emissions from barges operating along the Mississippi River in Louisiana were also reviewed. The first, an EPA-sponsored study, evaluated the use of remote sensing and ground-based measurements to identify short-term emissions from specific stacks, hatches, and valves on certain barges.[9] In this report, emissions were usually expressed in terms of grams per second, and the study appeared to focus on "gross leakers". While the emissions factors presented in the report may be representative of short term emissions from poorly controlled barges, the factors should not be used to estimate annual emissions from typical barges.

The second study, termed the "Carville Study," was sponsored by the American Waterway Operators (AWO) and the Louisiana Department of Environmental Quality, largely in response to the earlier EPA study.[10] This study also investigated ambient/source receptor concentrations of barge VOC emissions using an upwind/downwind sample design. Emissions were measured in units of parts per billion.

While both studies advanced the general state of knowledge regarding barge emissions and their possible leak points, neither study determined the emissions from typical barges.

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[9] see EPA 2009, 'Investigation of Fugitive Emissions from Petrochemical Transport Barges Using Optical Remote Sensing,' prepared by Eben Thoma, September 2009, EPA/600/R-09/136

[10] see LDEQ 2010, 'Carville Barge Monitoring Project,' February 2010, prepared for the US EPA

Therefore, they do not appear to be useful for developing emission factors for typical barges operating under low pressures.

## 4.2 Factors Influencing Barge Transit Emissions

Based on the review of available emission estimation methods, the following data inputs were identified for quantifying barge transit emissions:

- Product volumes by county/region, disaggregated by type to the extent possible;
- Product characteristics (vapor pressure vs. temperature, density);
- Ambient conditions by region and season (water and air temperatures, solar insolation);
- Barge trip counts and transit times;
- Distribution of loaded vs. empty trips;
- County level Geographic Information System (GIS) data to spatially allocate barge route data;
- Barge characteristic profiles, including:
  - Color
  - Vapor space volume, loaded and empty (with heel)
  - Tank configurations (volume/surface area/hull specifications)
  - Pressure valve specification and distribution
  - Product temperature

Based on the review of the API and TANKS emissions equations, product types and volumes, barge transit times, and pressure valve specifications were anticipated to have the greatest impact on emissions estimates. Nevertheless, an attempt was made to collect all of the above data to the extent possible, promoting the development of the most accurate barge transit inventory possible.

## 4.3 Data Sources

### 4.3.1 Available Data

Several sources of data were identified for the above modeling inputs. First, high quality barge activity data was obtained. Specifically, the U.S. Coast Guard collects detailed vessel movement data through the Vessel Traffic Service (VTS) in selected areas. VTS is operated by the Coast Guard to prevent harbor collisions, with data extracted from automatic information systems (AIS) in a dozen U.S. ports, utilizing radio reports (e.g., when going under a bridge), radar information, and similar sources to report trip originations and destinations. AIS tracks vessels for safety reasons and for the Department of Homeland Security, utilizing a massive

database of latitude/longitude recordings collected every 5 to 20 seconds, even when the boat or ship is stationary.

VTS data were obtained and processed for the two areas in Texas that have VTS capability, the HGB and the BPA study areas.[11] This data shows movements of tow strings, which typically include a tugboat with between 0 to 3 barges, along with designations for each barge indicating if the barge is loaded or empty. The data in the "tow configuration" column was used to determine the configuration of each tow string (e.g., an entry of "2L1E" indicates a configuration of two loaded barges and one empty barge). This data allows for the determination of barge counts, transit times, and spatial and temporal allocation. In addition, information regarding barge sizes was also provided with the HGB data. Since this data is cross-checked by AIS, radio dispatch, radar, and other means, it is of very high quality and can be used for emissions modeling purposes. However, product types and barge characteristics are not provided in the VTS data.

Although VTS data was not available for the Corpus Christi area, simple barge trip counts were obtained from the Port of Corpus Christi for evaluation.

Detailed GIS data was available from previous commercial marine evaluations conducted for the TCEQ for each coastal area of interest, along with county overlays.

The WCUS data maintained by the Corps of Engineers tracks loaded barge movements for transportation tax purposes. This data set is recommended for use in inventory development by the EIIP, containing information on "upbound," "downbound" and "through" barge traffic. The WCUS provides product tonnage by category, such as gasoline, diesel, crude oil, alcohols, benzene, toluene, and other chemicals. The WCUS lists thousands of tons of product by commodity code for tank barges. Since this data is voluntarily reported by barge operators who must pay a tax on moved products, its data quality is less certain, especially since there may be overlapping waterway segments. While the WCUS data is more disaggregated than the EIIP guidance approach (with about 15 product categories), it could benefit from additional disaggregation, especially for toxics speciation. However, there is no publicly available data allowing the WCUS product volume information to be linked with the VTS barge count data.

Information regarding product vapor pressure as a function of temperature was readily obtained from AP-42 and Perry's Chemical Engineer's Handbook.

[11] 2008 VTS data for March and April were missing from the HGB data, and were gap-filled using activity from adjacent months. Also, only 2009 data were available for the BPA region.

Reliable information regarding ambient conditions was readily obtained from the National Climatic Data Center (for air temperatures), and from the National Oceanic Data Center (for surface water temperatures), by location and season.

While general information is available regarding barge colors and pressure valve settings, detailed data was not publicly available regarding barge characteristics at the level required for this analysis.

### 4.3.2 Obtaining Additional Data

While data sources were identified for several required emissions calculation inputs, certain key data were not publicly available, as noted above. Accordingly, industry experts were identified to assist in determining the additional product distribution and barge characteristic profile information required to develop the barge inventory. To this end letters of introduction were delivered to the American Waterway Operators (AWO) and the Texas Waterway Operators Association (TWOA), summarizing the goals of the project and requesting their cooperation identifying technical experts for participation. The AWO is the national trade association representing the owners and operators of tugboats, towboats, and barges serving the waterborne commerce of the United States. (1) The TWOA represents 27 member companies, all owners and operators of marine equipment in Texas. (2)

Once contacted, a kickoff meeting was held with the industry representatives and technical area experts at the TCEQ offices in Austin on June 10, 2010 to obtain input regarding data requirements and possible sources of information. At this meeting the previous Louisiana DEQ and U.S. EPA barge emission studies were discussed with the stakeholders, who agreed that the results from these studies were not appropriate for characterizing “typical” barge transit emissions for this effort. The industry representatives also emphasized the substantial benefits that have likely been realized through the broad adoption of industry best management practices (BMP) over the last few years. In addition to anecdotal monitoring evidence regarding their effectiveness, it was noted that minimizing product loss is a continual incentive for all barge operators, for health and safety as well as economic reasons, as discussed above.

While some concerns were expressed regarding assumptions about vapor space saturation levels, and reservations regarding the accuracy of the AP-42/TANKS equations for control pressures above 2 psi, the group agreed that limited modification of the TANKS model should provide a reasonable basis for estimating barge transit emissions.[12] The industry representatives

[12] For example, one participant noted that empty barges do not approach full saturation levels in the vapor space.

also noted their opinion that water temperatures have a much greater influence upon barge product bulk temperatures than do the ambient air. In addition, it was noted that very large articulated and integrated barges rarely transport liquids inland. While evaluation of the HGB region VTS data found relatively few barges of these types, detailed information from Lloyd's Registry of Ships and the American Bureau of shipping frequently referenced petrochemical product transfers for these vessels. Accordingly these barge types were retained in the data set for emission inventory development.

The meeting participants stated that they would provide critical input regarding:

- Barge volumes, number and color;
- The distribution of pressure valve settings, correlated with product type, to the extent possible;
- Vapor space volumes, for both loaded and unloaded barges;
- Product volumes, disaggregated from the WCUS categorization to the extent possible;
- Test data regarding measured vapor saturation levels in empty barges.

The industry representatives concluded by recommending that the product list be grouped by general vapor pressure (e.g., < 1.0 psi, 1–2 psi, and 2-3 psi) in order to facilitate emissions modeling. In addition, the representatives also offered to identify certain product categories with vapor pressures low enough (e.g., < 0.5 psi) that breathing losses will be effectively negligible (since the vapor pressure will be lower than the minimum setting on any barge pressure relief devices), starting from the WCUS categorization scheme.

After this initial meeting a detailed set of questions was drafted to solicit the remaining required data inputs for the development of area-specific barge activity and emission rate profiles. Critical information was gathered to develop detailed commodity allocations to estimate specific commodity product volumes and movements, as well as corresponding emission factors.

The following presents the questions submitted to stakeholders from the American Waterway Operators (AWO) and the Texas Waterway Operators Association (TWOA) on July 1, 2010, along with their responses, provided July 23, 2010. Questions are shown in **bold**, and stakeholder responses are provided in *italics*. Comments regarding the responses are provided as well. The response information was integrated with additional input from the TCEQ in order to develop the proposed emission inventory methodology, as discussed in Section 5.

### 4.3.3 Industry Representative Responses

1. **In our proposed approach, total product volumes will be determined based on the number of loaded barges and trips reported in the Vessel Traffic Service (VTS) data obtained by ERG. However, we need a way of allocating total volumes by product type in order to develop emissions estimates. Does the U.S. Corps of Engineer's Waterborne Commerce of the United States (WCUS) provide a reasonable estimate of volumes by product category for the different study regions? (WCUS product estimates in millions of barrels per year are provided as a spreadsheet attachment). If not, can the information be adjusted, or would some other source of product volume data be more accurate?**

   *The WCUS data should be acceptable for characterizing the cargos handled and the quantity of each in the three areas of concern. On a volume % basis, the WCUS data could be applied to the traffic information from the VTS, but the VTS data does not specify barge volume. Therefore, a direct correlation of cargo gallons transported (WCUS) cannot be made to cargo trips made (VTS). Individually, these data sources are acceptable, but we will need to figure out a way to link them together for the study.*

   ERG comments: The VTS data provided for the HGB area did in fact provide barge dimensions, which can be used to estimate volumes. ERG proposes to use the distribution of barge sizes for this region to allocate product volumes for all study areas. WCUS product volumes will then be compared to the independent estimate developed using the VTS barge sizes, and noted accordingly in the study report.

2. **How can the WCUS product <u>groupings</u> be disaggregated further to allow for more accurate emissions estimation? (For example, can the "Benzene and Toluene" group be split out? What "Organic Comp. NEC" products can we break out?) How can we estimate product volumes for these disaggregated categories?**

   *At this time, the industry does not have any further detail on which specific cargos are categorized into each of the groups in the WCUS data. In the phone call between AWO/TWOA and ERG/TCEQ on July 15, it was mentioned that the cargo is categorized by ACOE when entering the self-reported data into their database. It would be worth asking ACOE to provide their database information, so that the cargo groups could be more accurately analyzed.*

   *The following are best guesses as to the chemicals that could be present in each of the general WCUS groups. Please understand that these are educated guesses at best and do not reflect a specific knowledge or understanding of how ACOE groups various cargos into their database.*

   *Acyclic Hydrocarbons - heptanes, decanes, heptene, hexane, nonene*

   *Alcohols - methanol, ethanol, isopropanol, butanols, decanol, hexanol, 2-ethylhexanol*

   *Benzene/Toluene - 50/50 each*

*Carboxylic Acids - acetic acid, propionic acid, butyric acid*

*Chemical Products NEC - assume these are heavy, non-volatile proprietary compounds (MW > 200)*

*Chemical Additives - assume these are heavy, non-volatile proprietary compounds (MW > 200)*

*Crude Petroleum - crude oil*

*Distillate Fuel Oils - #1 and #2 diesels, marine diesel oil, gas oil*

*Gasoline - natural gasoline, aviation gasoline, light straight run gasoline, unleaded gasoline (regular through premium grades), pyrolysis gasoline, reformate, raffinate*

*Kerosene - kerosene, jet fuel, jet naphtha, JP6*

*Naphtha and Solvents - wide range of medium weight refining cuts that are heavier than gasoline but lighter than diesel. These are typically unfinished products and could include: coker gas, cat gas, cracker feed stock, naphtha, heavier reformates and raffinates, alkylates. Assumed molecular weight range is 80-100; vapor pressure range is 0.5-3.0 psia.*

*Organic Compounds NEC - assume these are heavy, non-volatile proprietary compounds (MW > 200)*

*Organo-Inorganic Compounds - Not sure. Assume non-volatile*

*Other Hydrocarbons - Styrene, cumene, MEK, MTBE, butyl acrylate, vinyl acetate, xylene, propyl acetate, MIBK*

*Petroleum Products NEC - lube oil, light and heavy cycle oils, other heavier refining products*

*Residual Fuel Oil - residual fuel, No. 6 fuel oil, coker feed, vacuum gas, asphalt*

ERG Comments: ERG will use the above list, subject to TCEQ approval, to develop typical vapor pressure and density values for each major category listed above. We will also attempt to estimate the relative occurrence of the different product types within a given category, using publicly available, national level data. For example, we will attempt to find the annual production volumes for the different types of alcohols for use in developing weighted average (typical) vapor pressures for use with the TANKS model. In the absence of such data, we will select conservative (high vapor pressure) representatives for each category in order to proceed.

Note that ERG staff previously contacted the USCOE regarding the WCUS product categories, as suggested, and determined that no further information is available concerning the specifics of the product groupings.

ERG also sought the TCEQ's input regarding industry's "non-volatile" assumption for the following categories:

- Chemical Products NEC
- Chemical Additives
- Organic Compounds NEC
- Organo-Inorganic Compounds

If the industry recommendation is accepted, the emissions associated with these categories will be set to zero.

TCEQ comments: Based on the relatively low amounts of these products transported (each chemical accounted for 1% or less of the total volume of products transported in each of the project areas), the TCEQ accepts the industry recommendation.

**3. The surface temperature of the liquid product and the temperature of the vapor space may be influenced by a number of factors including initial product temperature at loading, the amount of underway agitation/mixing, water temperature, the presence or absence of double hulls, barge draft (both loaded and unloaded), ambient air temperatures, and the effect of solar incidence (primarily on vapor space air temperature). Considering the complex interactions of these factors we need to make simplifying assumptions to model the emissions. Based on your experience, what is the single most important factor in determining: a) surface temperature of the liquid product, and b) vapor space air temperature?**

*(a) For a loaded barge, the liquid surface will be above the water line and will be very close to the top of the cargo tank. Outside ambient temperature and the solar heat absorption from the paint color will impact the liquid surface temperature. However, 90% of the liquid is below the water line and is at the water temperature, thus providing cooling to the cargo liquid in the upper 10% above the water line. Solar absorption from paint color will not impact the temperature of barge cargo to the same extent that it will for an aboveground storage tank, given equivalent storage volumes. This should be accounted for somehow in the calculation of the bulk liquid and liquid surface temperatures.*

*For an empty barge, any remaining liquids in the discharge sump will be the same temperature as the water temperature, as these liquids are several feet below the water line.*

*(b) Vapor space air temperature for a loaded barge will be primarily driven by ambient air temperature.*

*For an empty barge, a significant portion of the vapor space will be at the ambient air temperature, because most of the barge hull will be above the water line. However, the vapor-liquid equilibrium layer will be located below the water line and will be driven by the water temperature.*

ERG comments: After review, ERG is investigating a slightly more complex treatment of thermal effects in order to estimate liquid surface and vapor space temperatures. First, we would begin by assuming that liquid product enters a barge at ambient temperatures, but will be cooled (at a rate to be estimated) by the water. It is unlikely that liquid temperatures will reach equilibrium with water temperatures though, given the relatively short duration of loaded barge trips (usually less than 8 hours).

We will also attempt to account for the fraction of transit miles that occur during ambient cooling periods, which would generally result in negative pressures. On the other hand, we do not propose modifying the TANKS model assumptions regarding solar absorption at the barge deck.

We agree that the heel in an empty barge will be at water temperature for the duration of the transit.

We will assume that the vapor space temperature on a loaded barge will begin at ambient but will tend toward equilibrium with the surface liquid temperature, give the vastly greater thermal inertia of the product. We will investigate the rate at which this change would occur, and make adjustments to account for trip length impacts if possible.

Regarding the vapor space in empty barges, we will assume ambient temperatures as suggested.

**4. Which product types may utilize inerting? What fraction of barges transporting these products have inerting systems, and what are their associated pressure ratings?**

*Industry members were not able to obtain enough detail on this item to provide accurate data for the study.*

ERG comments: ERG acknowledges this uncertainty.

**5. Is there any significant seasonal variation in the <u>distribution</u> of product volumes for the different regions? For example, do refinery turnarounds influence relative**

**product distributions in the spring and fall for certain areas? (Since we have barge counts by time of year, we can estimate absolute changes in <u>overall</u> product volumes by season, but we can't tell if the <u>relative</u> distributions across product types change over time.) Are some products transported only during certain times of the year?**

*Refineries typically produce more gasoline in the spring and summer and switch the emphasis of production to heating oil for the winter months. However, the quantities of these cargos transported do not significantly change such that seasonal production should be taken into account for the study.*

ERG comments: ERG agrees and will not make seasonal product volume adjustments for the inventory.

**6. During an initial stakeholder meeting at the TCEQ in June, an estimate was provided indicating loaded barges operate at 95 – 98% of capacity. Is this a reasonable estimate? In addition, what dimensions should we use for the different size barges (interior L x W x H) in order to estimate vapor space volumes? (Given the large number of possible configurations, developing generalized categories may be acceptable.) Finally, is there any pitch to the barge deck that would increase vapor space volumes?**

*97% loaded would be an acceptable average to use for all carriers. The following are the dimensions of the average 10,000; 20,000; and 30,000 barrel barge:*

*10,000 – 195'(L) x 35'(W) x 12'(D)*
*20,000 – 250'(L) x 50'(W) x 12'(D)*
*30,000 – 298'(L) x 54'(W) x 13'(D)*

*Cargo tanks are based on volumetric measurements, so any pitch to the top of the tank is accounted for when assuming 97% loaded.*

ERG comments: ERG will use these estimates to calculate product volume allocations using the VTS data.

**7. We need to estimate the fraction of barges with combinations of specific characteristics (e.g., red/30K barrel/2 lb) by product category. For each product type, can you provide barge characteristic distributions for the following parameters:**

**- color**
**- size/capacity**
**- pressure valve settings**

**For example, one possible set of distributional information would be:**

**Toluene barges –**

**100% red**
**80% 10K barrel / 20% 30K barrel**
**10% 6 lb / 80% 3 lb / 10% 2 lb**

**A blank template for completing this information is attached, although the product category list may need to be expanded based on your response to question 2. We also understand that data for certain "cells" within the template may not be readily available, and may have to be gap-filled in consultation with stakeholders and the TCEQ at a later time.**

*It is not possible to compile enough operational data in the time allotted to provide the data in the format requested. However, industry members did provide general trend information as described below.*

*Trends*
*Finished and specialty chemicals are typically handled in 10,000 barrel barges. Assume 85% in 10,000 barrel barges; 5% in 20,000 barrel barges; and 10% in 30,000 barrel barges for all finished chemical products.*

*Gasolines, kerosenes, and diesel fuels are typically handled in 30,000 barrel barges. Assume 20% in 20,000 barrel barges and 80% in 30,000 barrel barges.*

*Lube oils and heavy residual fuels are primarily transported in 10,000 barrel barges. Assume 90% in 10,000 barrel barges, 5% in 20,000 barrel barges, and 5% in 30,000 barrel barges.*

*Feedstocks such as naphthas and solvents are primarily transported in 30,000 barrel barges. Assume 90% in 30,000 barrel barges, 5% in 20,000 barrel barges, and 5% in 10,000 barrels barges.*

*Where possible, industry carries cargo in barges with pressure ratings at or above the vapor pressure of the material being transported. Review cargos for vapor pressure data*

*– any with a vapor pressure less than 1 psi will not emit in any barges, regardless of pressure rating. For cargos with a vapor pressure greater than 1psia but less than 3 psi, assume that 70% are transported in a 3psi barge and 30% are transported in a 1psi barge. For cargos with a vapor pressure above 3psi, assume 95% are transported in a 3psi barge and 5% are transported in a 6psi barge.*

*Paint colors vary by carrier and are not assigned to specific cargos. Carrier barge colors include red (587), gray (400), light green (106), black (20). Barges painted black only carry "black oil" products, such as asphalt and other very heavy refining cuts. There may be other barge colors that are not represented here. There may also more than the number represented for each of the colors identified above, but time constraints limited our ability to gather more detail. Given the paint solar absorptance factor for*

*these colors, it is not expected that more detailed would significantly change the average factor calculated from this data.*

ERG comments: ERG will use these assumptions in the inventory development task. We also agree that additional detail concerning the distribution of colors should not impact average solar absorption estimates significantly, as the absorption ratings of the above colors is fairly similar.

ERG will apply an adjusted TANKS methodology to estimate emissions as a function of pressure rating, as recommended in API bulletin 2516, Evaporation Loss from Low Pressure Tanks. ERG will provide additional detail regarding this approach under the Task 4 deliverable concerning the emission inventory methodology.

During the meeting with AWO/TWOA representatives in June, it was noted that some fraction of 6 psi barges have been "re-gauged" to make them compatible with dockside transfer systems, effectively converting them to 3 psi barges. Accordingly, ERG asked the stakeholders a follow up question to determine what fraction of 6 psi barges should be considered 3 psi barges. The stakeholders indicated that any 6 psi barges that have been de-rated to 3 psi barges have already been conservatively accounted for as 3 psi barges.

**8. Are the barge characteristics listed above correlated in any way? For example, are larger barges more or less likely to have higher pressure ratings than smaller barges? If so, how should we adjust the relative distributions to reflect these correlations?**

*There is no correlation between one construction characteristic and another.*

ERG comments: ERG will use average barge characteristic profiles across all sizes, pressures and colors.

**9. Is there any significant variation in barge type distributions across the three study areas (HGB, BPA, and Corpus Christi)? For example, are 6 lb barges operated only in the HGB area?**

*There is no significant variation in barge type used in any one specific area.*

ERG comments: ERG will use average barge type profiles across all areas.

**10. Do you have in-transit vapor space measurement data (for empty barges with heel, as well as loaded barges?) that can be provided to ERG as discussed during the TCEQ meeting?**

*No vapor space measurement data has been obtained for fully loaded barges, but since the liquid level is above the water line on a fully loaded barge, it is expected that the saturation percentage is very high for the vapor space (AP-42 calculations indicate 93-95%). For empty barges, where the small liquids collected in the suction sump and any small remaining clingage on the cargo tank walls will be below the water line, the vapor space concentration has been measured in a sampling study by one AWO member. Results from the study are attached to this response and indicate that the typical vapor space concentrations are well below saturation.*

ERG comments: No adjustments will be made for vapor pressures in loaded barges.

While the data provided from industry regarding vapor space saturation levels in empty barges does appear to indicate that vapor pressures are consistently below saturation, we do not believe there is enough data to clearly establish a relationship between temperature, vapor pressure, and percent saturation. Accordingly, we propose a very simple adjustment, assuming that all empty barges have a 50% saturation level. We seek TCEQ's input on this assumption.

TCEQ comments: The TCEQ agrees that all empty barges should be treated as having a 50% saturation level.

**11. Do you have any suggestions for further emission inventory improvements in the future?**

*This study has shed light to the large amount of specific data needed to calculate an area-wide emission inventory from the tank barge industry. The time allowed for this study required AWO and TWOA members to use industry knowledge, a limited amount readily available data, and averages/estimates for data instead of being able to collect all of the actual operating data needed to support TCEQ's calculations.*

ERG comments: ERG duly notes the extensive efforts of the AWO/TWOA, and acknowledges the associated time constraints.

Note that revised information was subsequently provided by the AWO regarding benzene and gasoline product distribtutions, as follows:

- Benzene: 10% 1 psi barges / 85% 3 psi barges / 5% 6 psi barges
- Gasoline: 25% 1 psi barges / 75% 3 psi barges / 5% 6 psi barges

# 5.0 Emission Inventory Development

## 5.1 Overview

Based on the prior review of available calculation methods, available data, and industry representative input, a four-step process was developed for estimating barge transit emissions for the study area.

1) *Identify ultra-low volatility and non-volatile product categories for exclusion.* Certain products carried by tank barges have essentially negligible vapor pressures, even under summertime (high temperature) conditions. As such, these products will not generate significant VOC emissions, regardless of barge pressure ratings. After consultation with industry stakeholders, the following WCUS product categories were assumed to include heavy, non-volatile proprietary compounds with molecular weight > 200. Given the lack of data regarding the specific products contained in these categories, these product categories were deemed to have extremely low vapor pressures and were categorically excluded from further analysis. Note that each of these categories made up 1% or less of the total product transported in each study area.

   - Chemical Products NEC[13]
   - Chemical Additives
   - Organic Compounds NEC
   - Organo-Inorganic Compounds

2) *Use API Bulletin 2516 "Evaporation Loss from Low-Pressure Tanks" to identify which products/barge pressure rating combinations will not result in breathing loss emissions.* For the volatile liquid products, the API emission loss equation (described in the following section) was used to determine the incremental increase in vapor space pressures considering the full range of anticipated product vapor pressures and temperature ranges for different months and locations. The results of these calculations determine the minimum vent pressure settings needed to prevent breathing losses for a particular product. Combining these results with the product/barge pressure rating assignments specified by industry representatives, one can determine which volatile products are not expected to generate breathing losses, regardless of time of year or location. For example, since hexane has a relatively high vapor pressure (~5 psi), according to industry guidance these products will always be assigned to 3 or 6 psi barges. Using the API Bulletin 2516 formula, it is seen that the maximum pressure increase associated with hexane barge movements is always less than 3 psi. Therefore, it can be concluded that properly operating hexane barges with a 3 psi pressure rating do not emit appreciable amounts of VOC during transit. Accordingly, hexane would be categorically excluded from evaluation of base case emissions,

[13] Not elsewhere classified

although hexane barge emissions would be estimated for an "uncontrolled" modeling scenario, as discussed in Section 6.

3) *Apply TANKS model equations to determine emission rates for all remaining product/barge psi combinations.* Emission factors are then estimated for all product types predicted to exceed barge pressure rating thresholds for some portion of anticipated operating conditions, using the TANKS model equations. Emission factors are expressed in terms of product volume transported per unit time. Separate emission factors will be developed to reflect different barge trip length distributions, as discussed in the following section.

4) *Combine product volume estimates with emission factors to obtain VOC and HAP/HRVOC emission estimates.* As discussed in detail below, WCUS product category volumes are first allocated across different product types (e.g., the "benzene and toluene" category is allocated as 50 percent benzene and 50 percent toluene), and then allocated to different barge pressure ratings. Next, an adjustment is made to remove product volumes transported during periods of the day when temperatures are falling (i.e., nighttime, assumed to be one third of total trips – see below for further discussion) and no breathing losses are expected. Product volumes are then further allocated across month and trip length bin, for combination with the emission factors generated using the TANKS equations. VOC mass emission estimates are then speciated to obtain HAP and HRVOC estimates, and finally allocated spatially to obtain county-level totals.[14] Note that this methodology does not require information regarding barge sizes, but simply relies on knowledge of total product volumes and relative vapor space volumes (i.e., 97 percent barge utilization for loaded barges).

## 5.2 Estimating Internal Pressures in Low Pressure Tanks

The API equation used to estimate internal pressure in a low pressure tank containing a particular volatile product is derived from the Ideal Gas Law and Raoult's Law, and is expressed as follows:

***Equation 1:*** $\mathbf{P_2 = (t_2/t_1) \times (P_a + P_1 - p_1) - (P_a - p_2)}$

*Where*

**$P_2$ = gauge pressure at which the pressure vent opens (psi)**
**$P_a$ = atmospheric pressure at sea level (14.7 psi)**
**$P_1$ = gauge pressure at which the vacuum vent opens (assumed = 0.0625 psi) (11)**
**$p_1$ = true vapor pressure at minimum surface temperature in deg. F, (psia)**
**$p_2$ = true vapor pressure at maximum surface temperature in deg. F, (psia)**
**$t_1$ = minimum avg. vapor space temperature (degrees R)[15]**

[14] Note that HRVOC emissions are a result of trace concentrations contained in mixtures of volatile liquid cargos, and do not represent direct emissions associated with HRVOC transport itself.
[15] Degrees Rankine = degrees Fahrenheit + 460

**$t_2$ = maximum avg. vapor space temperature (degrees R)**

In order to estimate the $P_2$ values for a particular WCUS product category, detailed information regarding product vapor pressures is needed. As noted above, the WCUS data provides aggregated information regarding broad categories of compounds (e.g., Acyclic Hydrocarbons), rather than a complete, detailed listing of all of the liquid products shipped by barge in the study areas. As such, representative compounds must be selected for some of the categories to facilitate emissions modeling. The choice of specific compounds to be used for modeling should consider three primary factors. First, the compounds selected should be representative of the WCUS categories in terms of volatility. Second, an estimate of the relative amounts of the different compounds is needed for each category. Third, reliable vapor pressure data must be available for each compound. This data must include the vapor pressure over the range of temperatures expected to be modeled.

Table 5-1 shows the compounds recommended for modeling for each of the WCUS product categories. These compounds were specifically referenced by industry representatives as examples of the products in a particular WCUS category. Complete vapor pressure data for the majority of the selected compounds was available from U.S. EPA's AP-42 emission factor tables or Perry's Chemical Engineer's Handbook, for a number of different temperatures. Vapor pressure data for the remaining compounds was developed using information from product material safety data sheets (MSDS), and then by proportional scaling from vapor pressures of similar compounds. Vapor pressure values were then linearly interpolated from available data to provide values in one degree (Fahrenheit) increments for liquid surface temperatures between 40 and 100 degrees, as shown in Appendix A. Since definitive information on the relative amounts of the various products within each category is not available, it is assumed that specific compounds contribute equal amounts to each WCUS category, as indicated in Table 5-1.

## Table 5-1. Selected Compounds by WCUS Product Category

| WCUS Category | Compounds Selected for Modeling (% Allocation) | Comments: |
|---|---|---|
| Acyclic Hydrocarbons | Hexane, Heptane, n-Decane, Nonene, and Heptene (20% each) | A range of light, mid-weight, and heavy compounds |
| Alcohols | Methanol, Ethanol, Isopropanol, Butanol, Decanol, Hexanol, and 2-Ethylhexanol (14% each) | A range of ultra-light, light, mid weight, and heavy compounds |
| Benzene & Toluene | Benzene and Toluene (50% each) | From industry |
| Carboxylic Acids | Acetic Acid, Propionic Acid, and Butyric Acid (33% each) | |
| Chemical Products NEC | N/A | Assume non-volatile * |
| Chemical Additives | N/A | Assume non-volatile * |
| Crude Petroleum | Crude Oil RVP 5 (100%) | As per API |
| Distillate Fuel Oil | #1 Diesel Fuel, #2 Diesel Fuel, and Marine Diesel (33% each) | |
| Gasoline | Gasoline – Various vapor pressures between 6 and 13 | RVP determined from regional sampling |
| Kerosene | Kerosene, Jet Kerosene, and Jet Naphtha (33% each) | |
| Naphtha & Solvents | Naphtha and JP-4 (50% each) | JP-4 is a substitute for "Solvents" |
| Organic Comp. NEC | N/A | Assume non-volatile * |
| Organo-Inorganic Comp. | N/A | Assume non-volatile * |
| Other Hydrocarbons | MEK, MTBE, Vinyl Acetate, MIBK, Propyl Acetate, Styrene, Xylene, Butyl Acrylate, and Cumene (11% each) | A range of light, mid, and heavy-weight compounds |
| Petroleum Products NEC | Lube Oils (100%) | Assume non-volatile * |
| Residual Fuel Oil | No. 6 Fuel Oil (100%) | Assume non-volatile * |

* Non-volatile compounds are defined as those products with a vapor pressure less than 0.1 psi at 100 degrees Fahrenheit. These products are expected to have negligible evaporative emissions during transport on a 1-pound barge under normal operating conditions.

As noted above, four WCUS categories were assumed to be effectively non-volatile. Therefore, these four categories were excluded from emissions modeling. Two other categories (Petroleum Products NEC and Residual Fuel Oil) were determined to have vapor pressures so low that, under normal conditions, they are not expected to have breathing loss emissions when transported by barge. These two product categories were modeled in order to determine if there were any conditions under which emissions would occur.

*Gasoline RVP Estimation*

Gasoline shipments require special attention, since gasoline itself consists of a complex mixture of chemicals, whose properties (such as vapor pressure) change by season.[16] Retail fuel sampling data was previously collected for the different study regions for the TCEQ in order to characterize summer and winter gasoline fuel properties for modeling.(12,13) Since these fuel samples contain oxygenates splash blended at distribution terminals, the measured Reid Vapor Pressure (RVP) must be adjusted to reflect the gasoline RVP levels associated with barge

[16] Due to state-mandated requirements intended to reduce VOC emissions during the ozone season.

shipments, before addition of oxygenates.[17] The oxygenates found in the retail gasoline samples included ethers (including ETBE – ethyl tertiary butyl ether, MTBE – methyl tertiary butyl ether,[18] and TAME – tertiary amyl methyl ether), and ethanol (EtOH).

The RVP of a fuel blended with a perfectly miscible oxygenate simply equals the sum of the RVPs of the individual components, weighted by their relative volumes. The ethers mentioned above were assumed to be completely miscible with gasoline.[19] Therefore the RVP of the gasoline before splash blending is calculated using the following formula:

***Equation 2:*** $\mathbf{RVP_{barge\ gas} = RVP_{retail} - (\text{volume fraction ETBE} \times RVP_{etbe} + \text{volume fraction MTBE} \times RVP_{mtbe} + \text{volume fraction TAME} \times RVP_{tame})}$

*Where*[20]

$\mathbf{RVP_{etbe} = 4.84}$

$\mathbf{RVP_{mtbe} = 9.26}$

$\mathbf{RVP_{tame} = 2.30}$

Ethanol is partially immiscible in gasoline. As such, the RVP of a gasoline-ethanol blend does not equal the weighted sum of the RVPs of the blend components. Using empirically derived relationships for gasoline-ethanol blends, the RVP of the pre-blend gasoline is calculated as follows:

***Equation 3:*** $\mathbf{RVP_{barge\ gas} = [RVP_{retail} - K_{EtOH}\ (0.24\ \text{volume fraction EtOH}) / (K_{gas}\ (1 - \text{volume fraction EtOH})]}$

*Where*

$\mathbf{K_{EtOH} = 0.96\ (\text{volume fraction EtOH})^{-0.8422}}$

$\mathbf{Kgas = -0.7\ (\text{volume fraction EtOH})^3 + 2\ (\text{volume fraction EtOH})^2 + 0.24\ (\text{volume fraction EtOH}) + 1}$

Source: SAE Paper 2007-01-4006

Table 5-2 summarizes the measured RVP and oxygenate levels for retail gasoline for the three different study regions, by season, along with the back-calculated RVP levels for the gasoline transported by barge, using Equations 2 and 3 above. Note that for this analysis

[17] RVP values are measured at 100 degrees F, by definition.

[18] The use of MTBE in gasoline was phased out beginning in 2006, but was found in the winter retail fuel sample from that year.

[19] No information regarding the miscibility of ethers in gasoline was identified in the literature or through US EPA's Office of Transportation and Air Quality.

[20] Ether RVP values from on-line MSDS reference material.

summer gasoline is assumed to be transported in barges between April and September, while winter gasoline is transported from October through March.[21]

**Table 5-2. Gasoline Oxygenate Levels and RVP by Study Region and Season**

| *Winter Gasoline Specifications* | | | | | |
|---|---|---|---|---|---|
| **Region** | **RVP (retail)** | **MTBE, % Vol** | **ETBE, % Vol** | **TAME, % Vol** | **$RVP_{barge\ gas}$** |
| BPA | 12.3 | 0.094 | 1.87 | 0 | 12.2 |
| HGB | 11.9 | 8.691 | 2.27 | 1.722 | 10.9 |
| CC | 12.5 | 0.000 | 2.17 | 0.024 | 12.4 |
| *Summer Gasoline Specifications* | | | | | |
| **Region** | **RVP (retail)** | **EtOH, % Vol** | **$K_{Etoh}$** | **$K_{gas}$** | **$RVP_{barge\ gas}$** |
| BPA | 7.2 | 2.01 | 25.815 | 1.006 | 6.1 |
| HGB | 7.0 | 5.30 | 11.403 | 1.018 | 5.8 |
| CC | 7.5 | ~0.0 | - | - | 7.5 |

*Maximum Pressure Determination*

Once the vapor pressure of all representative product categories is estimated for the full range of expected temperatures, these must be combined with estimates for the minimum and maximum vapor space and liquid surface temperatures to estimate the resulting pressure increase within the vapor space resulting from diurnal heating. Initial (minimum) liquid surface temperatures and vapor space temperatures are assumed to equal the 24 hour average ambient air temperature for a given month and region. Table 5-3 summarizes the pertinent temperature data by season and study region, along with related data on day length and solar insolation (discussed below).

[21] While the mandated summer fuel specification period is defined as May 15 – October 15, a six week lead time is assumed for barge traffic, to allow for adequate lead time between receipt at the coast and ultimate distribution at the retail station.

## Table 5-3. Air and Water Temperatures by Month and Region

| | | | Temperatures in Degrees Fahrenheit | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trip Region** | **Parameter** | **Units** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **HOUSTON** | **MAX Air Temp** | **Deg. F** | 62.3 | 66.5 | 73.3 | 79.1 | 85.5 | 90.7 | 93.6 | 93.5 | 89.3 | 82 | 72 | 64.6 |
| **HOUSTON** | **MIN Air Temp** | **Deg. F** | 41.2 | 44.3 | 51.3 | 57.9 | 66.1 | 71.8 | 73.5 | 73 | 68.4 | 58.8 | 49.8 | 42.8 |
| **HOUSTON** | **Temp Delta** | **Deg. F** | 21.1 | 22.2 | 22 | 21.2 | 19.4 | 18.9 | 20.1 | 20.5 | 20.9 | 23.2 | 22.2 | 21.8 |
| **HOUSTON** | **AVG Air Temp** | **Deg. F** | 51.8 | 55.4 | 62.3 | 68.5 | 75.8 | 81.3 | 83.6 | 83.3 | 78.9 | 70.4 | 60.9 | 53.7 |
| **HOUSTON** | **Insolation** | **Btu/ft2/day** | 772 | 1034 | 1297 | 1522 | 1775 | 1898 | 1828 | 1686 | 1471 | 1276 | 924 | 730 |
| **HOUSTON** | **Day Length** | **Hours** | 10.55 | 11.32 | 12.15 | 13.05 | 13.77 | 14.05 | 13.77 | 13.05 | 12.15 | 11.28 | 10.53 | 10.23 |
| **HOUSTON** | **Insolation/Hr** | **Btu/ft2/hr** | 73.18 | 91.37 | 106.75 | 116.63 | 128.93 | 135.09 | 132.78 | 129.20 | 121.07 | 113.09 | 87.72 | 71.34 |
| **HOUSTON** | **Temp Delta/Hr** | **Deg. F** | 2.67 | 2.62 | 2.41 | 2.17 | 1.88 | 1.79 | 1.95 | 2.09 | 2.29 | 2.74 | 2.81 | 2.84 |
| **HOUSTON** | **Water Temp** | **Deg. F** | 53.50 | 55.50 | 61.50 | 71.00 | 77.50 | 82.50 | 85.00 | 85.50 | 82.50 | 75.00 | 66.50 | 59.00 |
| **GALVESTON** | **MAX Air Temp** | **Deg. F** | 61.9 | 64.4 | 70 | 75.2 | 81.4 | 86.6 | 88.7 | 89.3 | 86.5 | 79.7 | 71.3 | 64.3 |
| **GALVESTON** | **MIN Air Temp** | **Deg. F** | 49.7 | 51.5 | 58.2 | 64.7 | 72.3 | 77.8 | 79.8 | 79.5 | 75.6 | 68.4 | 59.4 | 51.8 |
| **GALVESTON** | **Temp Delta** | **Deg. F** | 12.2 | 12.9 | 11.8 | 10.5 | 9.1 | 8.8 | 8.9 | 9.8 | 10.9 | 11.3 | 11.9 | 12.5 |
| **GALVESTON** | **AVG Air Temp** | **Deg. F** | 55.8 | 58 | 64.1 | 70 | 76.9 | 82.2 | 84.3 | 84.4 | 81.1 | 74.1 | 65.4 | 58.1 |
| **GALVESTON** | **Insolation** | **Btu/ft2/day** | 772 | 1034 | 1297 | 1522 | 1775 | 1898 | 1828 | 1686 | 1471 | 1276 | 924 | 730 |
| **GALVESTON** | **Day Length** | **Hours** | 10.55 | 11.32 | 12.15 | 13.05 | 13.77 | 14.05 | 13.77 | 13.05 | 12.15 | 11.28 | 10.53 | 10.23 |
| **GALVESTON** | **Insolation/Hr** | **Btu/ft2/hr** | 73.18 | 91.37 | 106.75 | 116.63 | 128.93 | 135.09 | 132.78 | 129.20 | 121.07 | 113.09 | 87.72 | 71.34 |
| **GALVESTON** | **Temp Delta/Hr** | **Deg. F** | 1.54 | 1.52 | 1.29 | 1.07 | 0.88 | 0.84 | 0.86 | 1.00 | 1.20 | 1.34 | 1.51 | 1.63 |
| **GALVESTON** | **Water Temp** | **Deg. F** | 53.50 | 55.50 | 61.50 | 71.00 | 77.50 | 82.50 | 85.00 | 85.50 | 82.50 | 75.00 | 66.50 | 59.00 |
| **PORT ARTHUR** | **MAX Air Temp** | **Deg. F** | 61.5 | 65.3 | 72 | 77.8 | 84.3 | 89.4 | 91.6 | 91.7 | 88 | 80.5 | 70.9 | 63.9 |
| **PORT ARTHUR** | **MIN Air Temp** | **Deg. F** | 42.9 | 45.9 | 52.4 | 58.6 | 66.4 | 72.3 | 73.8 | 73.2 | 69.4 | 59.6 | 50.8 | 44.5 |
| **PORT ARTHUR** | **Temp Delta** | **Deg. F** | 18.6 | 19.4 | 19.6 | 19.2 | 17.9 | 17.1 | 17.8 | 18.5 | 18.6 | 20.9 | 20.1 | 19.4 |
| **PORT ARTHUR** | **AVG Air Temp** | **Deg. F** | 52.2 | 55.6 | 62.2 | 68.2 | 75.4 | 80.9 | 82.7 | 82.5 | 78.7 | 70.1 | 60.9 | 54.2 |
| **PORT ARTHUR** | **Insolation** | **Btu/ft2/day** | 772 | 1034 | 1297 | 1522 | 1775 | 1898 | 1828 | 1686 | 1471 | 1276 | 924 | 730 |
| **PORT ARTHUR** | **Day Length** | **Hours** | 10.55 | 11.32 | 12.15 | 13.05 | 13.77 | 14.05 | 13.77 | 13.05 | 12.15 | 11.28 | 10.53 | 10.23 |
| **PORT ARTHUR** | **Insolation/Hr** | **Btu/ft2/hr** | 73.18 | 91.37 | 106.75 | 116.63 | 128.93 | 135.09 | 132.78 | 129.20 | 121.07 | 113.09 | 87.72 | 71.34 |
| **PORT ARTHUR** | **Temp Delta/Hr** | **Deg. F** | 2.35 | 2.29 | 2.15 | 1.96 | 1.73 | 1.62 | 1.72 | 1.89 | 2.04 | 2.47 | 2.54 | 2.53 |
| **PORT ARTHUR** | **Water Temp** | **Deg. F** | 53.50 | 55.50 | 61.50 | 71.00 | 77.50 | 82.50 | 85.00 | 85.50 | 82.50 | 75.00 | 66.50 | 59.00 |
| **CORPUS CHRISTI** | **MAX Air Temp** | **Deg. F** | 66 | 69.7 | 75.8 | 80.7 | 85.6 | 90.2 | 93.2 | 93.4 | 89.9 | 83.6 | 74.9 | 68 |
| **CORPUS CHRISTI** | **MIN Air Temp** | **Deg. F** | 46.2 | 49.3 | 56.2 | 62.3 | 69.5 | 73.5 | 74.4 | 74.5 | 71.6 | 64 | 55.4 | 48.1 |
| **CORPUS CHRISTI** | **Temp Delta** | **Deg. F** | 19.8 | 20.4 | 19.6 | 18.4 | 16.1 | 16.7 | 18.8 | 18.9 | 18.3 | 19.6 | 19.5 | 19.9 |
| **CORPUS CHRISTI** | **AVG Air Temp** | **Deg. F** | 56.1 | 59.5 | 66 | 71.5 | 77.5 | 81.9 | 83.8 | 83.9 | 80.8 | 73.8 | 65.1 | 58.1 |
| **CORPUS CHRISTI** | **Insolation** | **Btu/ft2/day** | 898 | 1147 | 1430 | 1642 | 1866 | 2094 | 2186 | 1991 | 1687 | 1416 | 1043 | 845 |
| **CORPUS CHRISTI** | **Day Length** | **Hours** | 10.68 | 11.38 | 12.15 | 12.98 | 13.63 | 13.90 | 13.63 | 12.98 | 12.16 | 11.35 | 10.67 | 10.38 |
| **CORPUS CHRISTI** | **Insolation/Hr** | **Btu/ft2/hr** | 84.06 | 100.76 | 117.70 | 126.47 | 136.87 | 150.65 | 160.34 | 153.35 | 138.75 | 124.76 | 97.78 | 81.38 |
| **CORPUS CHRISTI** | **Temp Delta/Hr** | **Deg. F** | 2.47 | 2.39 | 2.15 | 1.89 | 1.57 | 1.60 | 1.84 | 1.94 | 2.01 | 2.30 | 2.44 | 2.56 |
| **CORPUS CHRISTI** | **Water Temp** | **Deg. F** | 55.5 | 58.5 | 64 | 73 | 78 | 82.5 | 84.5 | 85 | 82.5 | 75.5 | 67.5 | 60.5 |

**References:**
Maximum Temperature 1971-2000
Source: http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmmax.txt
Minimum Temperature 1971-2000
Source: http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmmin.txt
Average Temperature 1971-2000
Source: http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmavg.txt
Solar Insolation
Source: US EPA 2006. AP 42, Chapter 7.1, Table 7.1-7, November 2006. Data has units of Btu/ft2/day.
Assume solar insolation in Houston is equivalent to insolation in Galveston and Port Arthur
Water Temperature
Source: http://www.nodc.noaa.gov/dsdt/cwtg/wgof.html
Galveston and Freeport temperature data is averaged and used as a surrogate for Houston.
Freeport and Port Mansfield temperature data is averaged and used as a surrogate for Corpus Christi.

The maximum liquid surface and vapor space temperatures depend upon the amount of radiant energy transferred into the barge itself, which varies with trip length duration, time of year, and study region.[22] The TANKS model provides equations to calculate changes in both liquid surface temperature and vapor space temperature as a function of solar insolation and other factors, as described in Section 5.3. Once determined, temperature and vapor pressure inputs are combined using Equation 1 to estimate the internal tank pressure increase associated with each product type/trip length/month/region combination. The detailed results from these calculations are presented in Appendix B.

Table 5-4 summarizes the maximum pressure increases calculated for any product within a particular trip length bin and region. As shown in the table, trip lengths 3 hours or less in duration never have vapor space pressure increases exceeding 1 psi, and pressure increases never exceed 3 psi, regardless of product vapor pressure or trip length. Therefore breathing loss VOC emissions are only anticipated for 1 psi barges under normal operating conditions. Different trip length bins were applicable to different areas, resulting in several "not applicable" entries in the table.

**Table 5-4. Maximum Pressure Increase by Trip Length Bin and Study Region (psi)**

| | *Trip Length Bin (hours)* | | | | | | |
|---|---|---|---|---|---|---|---|
| **Region** | **1** | **2** | **3** | **5** | **6** | **9** | **16** |
| HGB | N/A | 0.510 | N/A | N/A | N/A | 1.736 | 2.634 |
| BPA | 0.285 | N/A | 0.705 | N/A | 1.809 | N/A | N/A |
| Corpus Christi | N/A | N/A | N/A | 2.922 | N/A | N/A | N/A |

## 5.3 TANKS Model Breathing Loss Emission Factors

As noted above, the TANKS model has certain limitations with respect to estimating transit emissions from barges. First, Appendix D to the User's Guide to TANKS states that TANKS may not be appropriate to model emissions from low-pressure vessels.[23] Another consideration is that TANKS is designed to model the breathing, standing and working losses from above ground storage tanks that have the majority of their surface area exposed to air, and which experience wide temperature changes on a daily basis. However, loaded barges typically have the majority of their surface area exposed to water, which does not change temperature markedly on a daily basis. In order to address these limitations, the source material for TANKS (presented in Chapter 7.1 of AP-42) was used to obtain specific model emission formulas. These

[22] Trip length distributions vary across study regions, and are binned into discrete groups, such as trips less than 2 hours, trips between 2 and 9 hours, etc., as discussed in Section 5.4.

[23] This concern is minimized somewhat since only very low pressure (1 psi) barges are modeled under this approach.

formulas were then input into a spreadsheet to allow parameters to be adjusted to model the unique conditions presented by low-pressure barges.

The following describes how the pertinent equations from the TANKS model were used. In several cases simplifying assumptions were made in order to reduce the complexity and data processing time required to develop comprehensive emissions estimates.

*Liquid Surface Temperature*

Liquid surface temperature is a primary determinant of product vapor pressures. This analysis assumes that the initial liquid temperature at the start of a barge trip is equal to the average daily air temperature. Surface temperatures will rise during the course of a trip due to solar heating, as calculated below.

***Equation 4:*** $\mathbf{T_{la} = 0.44\ T_{aa} + 0.56\ T_b + 0.0079\ \alpha\ I}$

*Where*

**$T_{la}$ = liquid surface temperature (°R)**
**$T_{aa}$ = daily average ambient temperature (°R)**
**$T_b$ = liquid bulk temperature (°R)[24]**
**$\alpha$ = tank paint solar absorptance, dimensionless**
**I = daily total solar insolation factor (Btu/(ft$^2$ day))**

Daily average ambient temperatures ($T_{aa}$), along with daily maximum ($T_{ax}$) and daily minimum temperature ($T_{an}$), are used as factors in the TANKS equations. This data was gathered from NOAA's National Climatic Data Center for Houston, Port Arthur, Galveston, and Corpus Christi. (14) For this assessment, initial liquid bulk temperatures are assumed to equal daily average ambient air temperatures, which are provided for each region and month in Table 5-3.

Heating rates for liquid surface temperatures are also influenced by tank paint solar absorptance (α) and solar insolation (I) factors. Barge deck color is used to estimate tank paint solar absorptance (α). Together, the tank paint solar absorptance (α) and solar insolation (I) factors appear in three places in the overall TANKS model emissions equation. Industry representatives supplied estimates of the distribution of barge colors in operation in the study areas. A simplifying assumption was made to estimate a single average absorptance factor for the barge fleet as a whole, weighted by the prevalence of different colors reported by industry.

[24] Also the liquid surface temperature at trip start.

This average value (0.77) was then used as the tank paint solar absorptance factor in all equations. Table 5-5 presents the barge color distribution used to calculate the weighted average absorptance factor. Note that absorptance factors vary somewhat depending upon the condition of the paint. For this analysis, it was conservatively assumed that 25 percent of all barge paint is in poor condition, although industry representatives noted that paint is generally kept in good condition through regular maintenance activities.[25]

**Table 5-5. Barge Color Distribution and Absorptance Factors**

| Paint Color | Paint Condition | Absorptance Factor | Fraction |
|---|---|---|---|
| Red | Good | 0.89 | 0.40 |
| Red | Poor | 0.91 | 0.13 |
| Medium Gray | Good | 0.68 | 0.14 |
| Medium Gray | Poor | 0.74 | 0.05 |
| Light Gray | Good | 0.54 | 0.14 |
| Light Gray | Poor | 0.63 | 0.05 |
| Light Green | Good | 0.60 | 0.07 |
| Light Green | Poor | 0.70 | 0.02 |
| | **Weighted Average** | **0.77** | |

Daily solar insolation (I) is used in the TANKS model emissions equation to account for heating of liquid surfaces by the sun's radiant energy. Information on average daily solar insolation for each month was collected for the Corpus Christi and Houston regions from AP 42, Chapter 7. (15) Values for the Houston area are used for the Beaumont region. Table 5-3 presents the solar insolation values for each month by region.

Note that solar insolation only occurs during daylight hours when the sun is above the horizon, and is typically strongest at midday. Since barge trips may begin at any time during the 24-hour daily cycle, and many barge trips are short (four hours or less), fractions of the full daily solar insolation are used in the emissions equations for short trips.

Although not calculated by the TANKS model, it is possible that product temperatures will be affected by surrounding water temperatures. However, a simplified analysis of heat transfer found that the cooling effect of the surrounding water on liquid barge cargo should be minimal over a 24-hour period for standard double-hull barges, as the cargo hold is well-insulated from the water by an air space (see Appendix C for a description of the calculation methodology and findings). Since roughly 90% of currently operating barges now have double-hull construction, no adjustments were made to the calculations. (16) Also, note that while it is

[25] Adjusting the paint condition assumption to "100 percent good" results in a small change in the fleet average absorptance factor (from 0.77 to 0.71), and therefore was not modeled as a separate scenario.

unclear if there is significant mixing between the surface layer of liquid and layers below due to agitation during transport, this modeling approach assumed no mixing over time.

*Vapor Density*

The following equation calculates the vapor density for a given product.

***Equation 5:*** $\mathbf{W_v = (M_v\ P_{va}) / (R\ T_{la})}$

*Where*

**$W_v$ = vapor density (lbs/ft$^3$ of vapor space)**

**$M_v$ = vapor molecular weight (lb/lb-mole)**

**R = ideal gas constant (10.731 psia ft$^3$/lb-mole °Rankine)**

**$P_{va}$ = vapor pressure at daily average liquid surface temperature (psia)**

**$T_{la}$ = daily average liquid surface temperature (°Rankine)**

Molecular weights are presented in Appendix A, along with product vapor pressures estimated for temperatures between 40 and 100 °F. Daily average liquid surface temperatures are calculated using Equation 4.

*Vapor Temperature Range*

The pressure increase within a barge is largely determined by the vapor space temperature increase due to solar insolation and ambient temperature changes. The vapor temperature range for a given trip length, region, and month is calculated using Equation 6.

***Equation 6:*** $\mathbf{\Delta T_v = 0.72\ \Delta T_a + 0.028\ \alpha\ I}$

*Where*

**$\Delta T_v$ = vapor temperature range (°R)**

**$\Delta T_a$ = ambient temperature range (°R)**

**$\alpha$ = tank paint solar absorptance, dimensionless**

**I = total solar insolation (Btu/ft$^2$/trip length)**

Ambient temperature ranges for a given trip length assume that temperatures rise linearly from their minimum to their maximum values over the entire range of daylight hours for a given

month and region.[26] Similarly, total solar insolation for a given trip length is assumed to accumulate at a constant rate per hour for the full portion of the trip made during daylight hours.

*Vapor Space Expansion Factors*

The vapor space expansion factor ($K_e$) is a dimensionless parameter related to the thermal expansion of the gas within the barge.

***Equation 7:*** $\mathbf{K_e = (\Delta T_v / T_{la}) + ((\Delta P_v - \Delta P_b) / (P_a - P_{va})}$[27]

*Where*

**$\Delta T_v$ = vapor temperature range per trip length (°R)**

**$\Delta P_v$ = vapor pressure range per trip length (psi)**

**$\Delta P_b$ = breather vent pressure setting range (psi)**

**$P_a$ = atmospheric pressure (14.7 psia)**

**$P_{va}$ = vapor pressure at daily average liquid surface temperature (psia)**

**$T_{la}$ = daily average liquid surface temperature (°R)**

In the above equation, the change in vapor temperature over a given trip length is calculated using Equation 6. Vapor pressure increases are determined from the vapor pressures associated with the minimum and maximum liquid surface temperatures, expressed in Equation 4. The breather vent pressure setting equals the nominal barge pressure rating (1 psi for 1 psi barges, as determined in Section 5.2), less the vacuum vent settings (assumed to be 0.0625 psi, the API Bulletin 2516 default value for a low-pressure vessel).

*Vapor Space Saturation Factor*

The vented vapor space saturation factor is a dimensionless parameter indicating the relative amount of product vapor in the vapor space, and is associated with the vapor space dimension and product vapor pressure, as expressed in Equation 8.

***Equation 8:*** $\mathbf{K_s = 1 / (1 + 0.053\ P_{va}\ H_{vo})}$

*Where*

**$K_s$ = vented vapor saturation factor, dimensionless**

**$P_{va}$ = vapor pressure at daily average liquid surface temperature (psia)**

**$H_{vo}$ = vapor space outage (ft)**

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[26] This assumption could be refined in the future to reflect a more accurate non-linear heating cycle, although the net effect on estimated emissions levels is expected to be relatively small.

[27] If the expression < 0, $K_e = 0$.

**0.053 = constant (psia-ft)$^{-1}$**

In the above equation, vapor space outage refers to the height of the vapor space, set equal to 3 percent of the cargo volume. For this analysis a loaded barge with a cargo volume 10 feet in depth would have a vapor space outage of 0.30 feet. Vapor space outage is drastically different for empty barges, equaling in effect the full 10 feet. Note that the vapor saturation levels are typically greater than 90 percent for all product types, months and regions for loaded barges (see Appendix D). However, vapor saturation levels are predicted to be much lower for empty barges, with certain products such as benzene with saturation levels at roughly 50 percent. These lower values are generally consistent with the measured values provided by industry representatives based on independent grab samples.[28]

*Breathing Loss Emission Factors*

Breathing loss emission factors for a given product volume/trip length combination are estimated using the following equation.

***Equation 9:*** $\mathbf{L_s = V_v\, W_v\, K_e\, K_s / 0.1781}$

*Where*

**$L_s$ = breathing loss (lb VOC/bbl product/month)**
**$V_v$ = vapor space volume ($ft^3$ per $ft^3$ of product)**
**$W_v$ = stock vapor density (lb VOC/$ft^3$)**
**$K_e$ = vapor space expansion factor, dimensionless**
**$K_s$ = vented vapor saturation factor, dimensionless**
**0.1781 = volume conversion factor (bbl (oil) / $ft^3$)**

At 97 percent utilization for loaded barges, the vapor space volume per $ft^3$ of product equals 0.03/0.97, or 0.031. For empty barges the vapor space volume per $ft^3$ of product equals 1.0/0.97, or 1.031. By multiplying $L_s$ values by the appropriate product volumes (in bbl/month), VOC mass emission estimates are obtained. The determination of product volumes is discussed in the following section.

Emission factor tables were developed for each product type, trip length bin, and region. Due to differences in ambient air temperatures, different emission factors were developed using data for Houston and Galveston, as shown in Table 5-3. In order to simplify the emission

[28] From confidential industry test data regarding benzene and similar hydrocarbons.

inventory calculation process, the emission factors for Houston and Galveston were simply averaged for combination with the HGB WCUS product volume data.

## 5.4 Activity Factors

Activity factors were developed for barge movements at the county level, in terms of barrels of product per month for different trip length categories, as described below.

*Barge Counts*

There were a variety of options for estimating the number of barges in operation in the study areas and determining associated product volumes. Traditionally, data from the WCUS has been used, as recommended by the EIIP. However, WCUS data lacks spatial resolution and does not monitor empty barge movements at the level required for this study. Therefore, as discussed in Section 4, VTS data for barges was obtained for the BPA and HGB areas. As the Corpus Christi area does not have a VTS tracking database, the Port of Corpus Christi was contacted to supply its harbor master data for barges.

The activity data was first filtered to identify towboat configurations that were likely to be marine tank barges. Codes for deck barges, crane barges, bulk barges, pipe barges, and dredge barges were excluded from the GIS routing network. Note that the VTS data included some very large, ocean-going barges including:

- Ocean line-haul towboats with large tank barges
- Ocean pushboats with large tank barges
- Articulated tug/barge (ATB) combination rigs
- Integrated tug/barge (ITB) combo rigs that resemble small ships but do separate the tug and barge

The VTS data reports each towboat/barge movement, but towboats routinely move multiple barges simultaneously, usually between two to six barges at a time. Using VTS codes, the number of empty and loaded barges were determined for every towboat/barge movement. The average ratio of loaded to empty barges calculated for the HGB and BPA regions was used for the Corpus Christi area, given the lack of VTS data for that region.

*Barge Volume Estimation*

Loaded barge volumes were estimated directly from the WCUS product amounts for each study region. The WCUS data reports product tonnage. In order to convert these values to product volumes, liquid densities were compiled for each representative product category, and

weighted by the assumed product distribution within each WCUS category (see Table 5-1.) The product densities and associated volumes are presented in Table 5-6 for each study region.

**Table 5-6. Product Densities and Volumes by Region (2008)**

| Product Volumes (Barrels)* | | | | | |
|---|---|---|---|---|---|
| **Product Name** | **Wtd Avg Density (lb/gal)** | **BPA** | **Corpus Christi** | **HGB** | **State Total** |
| Acyclic Hydrocarbons | 5.86 | 9,858,381 | 5,869,623 | 16,259,408 | 31,987,412 |
| Alcohols | 7.07 | 9,570,097 | 3,886,346 | 29,858,766 | 43,315,208 |
| Benzene & Toluene | 7.31 | 18,340,893 | 11,981,902 | 46,322,623 | 76,645,417 |
| Carboxylic Acids | 8.35 | 2,645,053 | 1,090,044 | 8,978,536 | 12,713,632 |
| Crude Petroleum | 7.10 | 54,601,497 | 20,799,495 | 49,392,212 | 124,793,204 |
| Distillate Fuel Oil | 7.00 | 97,663,053 | 69,305,178 | 126,806,872 | 293,775,104 |
| Gasoline | 5.60 | 62,040,007 | 69,415,424 | 74,479,943 | 205,935,374 |
| Kerosene | 6.80 | 279,505 | 173,852 | 647,888 | 1,101,245 |
| Naphtha & Solvents | 6.33 | 49,536,395 | 20,952,976 | 57,941,775 | 128,431,147 |
| Other Hydrocarbons | 7.08 | 26,273,131 | 28,967,276 | 47,286,843 | 102,527,250 |
| Petro. Products NEC | 7.51 | 10,758,619 | 3,806,448 | 14,981,666 | 29,546,733 |
| Residual Fuel Oil | 7.90 | 55,449,662 | 49,360,303 | 106,606,551 | 211,416,516 |
| *Volumes have been adjusted to allocate ICW product volumes to each area based on ICW trip distances. | | | | | |
| *Volumes have been adjusted to reflect only the product volumes that are transported during daylight hours, when heating is occurring, which is approximately 67% of the total volume. | | | | | |

Although empty barges emit VOCs similar to loaded barges, they do not carry product and therefore cannot use WCUS-derived product volumes as their associated activity measure. If there are equal numbers of loaded and empty barge-hours traveled in a given region, then WCUS product volumes can be used directly to estimate total vapor space volume transits. In fact, this assumption was made for the Corpus Christi area, given its simple routing layout. However, the VTS data indicated that for HGB and BPA areas, empty barge trips were more common than loaded ones, perhaps due to fleeting operations and moving empty barges for later dispatch. Therefore simple ratios of empty to loaded barge trips were developed for each region - 1.39 for HGB and 1.16 for BPA. These ratios were then applied to the WCUS product volumes for each region to estimate total vapor space volume-hours traveled for empty barges in these areas.

*Transit Time Estimation*

VTS and Port information requires Automated Identification System (AIS) data in order to precisely determine vessel speeds. However, AIS data was not available for this project. Therefore, in order to determine transit times for product volumes, the channels for each port were assigned waypoints and channel segments, and reported barge traffic volumes were summed for each segment. Transit times were estimated based on an assumed speed of 6 knots (based on ERG staff familiarity with marine operations in the study regions). Using an adjustment to account for slowing and maneuvering at docks, average speeds were slightly less than 6 knots. Dock arrivals assumed a speed of 3 knots on the last approach for the HGB region, and alternatively, an additional half an hour for maneuvering in the BPA region. By dividing segment distances by these assumed speeds, hours of transit time were obtained for each waterway segment, trip, and barge type (empty or loaded). Different averaging methods resulted in slightly different transit times, and a sensitivity analysis found that results varied by +/- 15 percent depending upon which grouping method was employed.

Barge trips were ultimately grouped into trip length bins for each region that represented relatively discrete groups of trips, as shown in the trip length distribution data. The analysis of barge shipments indicates that the majority of trips are just a few hours in length. It is important to note the change in temperature over a few hours is not as large as that experienced over a full daily heating period. Also, with random starting times, trips may occur during times when temperatures are stable, rising, or falling. To account for these cases, total product shipments were divided proportionally into bins of differing trip lengths, and the emissions for these trips were modeled using fractions of the total daily temperature change and total daily solar insolation. As changes in temperature and insolation across the 24-hour day are nonlinear and therefore too complex to model accurately, simplifying assumptions were made for these variables, namely:

- all days in a month are equivalent to the day length (sunrise to sunset) on the 21st day of that month;
- incremental changes in temperature over time (from minimum to maximum and back to minimum) are equally distributed across a 24 hour cycle, and;
- increments of solar insolation are equally distributed across the period of daylight hours.

Tables 5-7 and 5-8 summarize the trip length distributions and bins for the HGB and BPA study areas. The calculation for the HGB area used the available barge size data for that region to weight the trip distribution percentages by product volume. Since barge size information was not available for the BPA region, the trip length distribution for this region was

based solely on total barge hours of operation. The Corpus Christi region was estimated to have very uniform trip length distributions, tightly centered around 5 hours. These distribution percentages were used to allocate WCUS-based product volumes across the different trip length bins, for combination with the corresponding emission factors.

**Table 5-7. Barge Trip Length Distribution, HGB Region**

| Trip Length (hrs) | Loaded Trips | Avg Hours | Avg Miles | Avg Speed (nautical mph) | Avg Barrels | Loaded BBLs | Volume% by Trip Length Bin |
|---|---|---|---|---|---|---|---|
| 1 | 15,908 | 0.68 | 1.7 | 2.50 | 43,039 | 684,665,007 | 48.9% |
| 2 | 4,060 | 1.59 | 6.5 | 4.09 | 39,788 | 161,518,894 | |
| 3 | 1,392 | 2.55 | 13.4 | 5.25 | 30,966 | 43,089,125 | 22.2% |
| 4 | 547 | 3.46 | 19.4 | 5.61 | 27,108 | 14,814,631 | |
| 5 | 245 | 4.46 | 25.2 | 5.65 | 26,682 | 6,537,176 | |
| 6 | 206 | 5.58 | 31.3 | 5.61 | 26,372 | 5,432,672 | |
| 7 | 794 | 6.43 | 37.6 | 5.85 | 38,060 | 30,200,949 | |
| 8 | 157 | 7.56 | 42.1 | 5.57 | 56,197 | 8,794,798 | |
| 9 | 2,600 | 8.74 | 51.1 | 5.85 | 49,530 | 128,753,559 | |
| 10 | 95 | 9.55 | 50.9 | 5.33 | 75,609 | 7,145,025 | |
| 11 | 187 | 10.67 | 60.6 | 5.68 | 34,535 | 6,458,133 | |
| 12 | 71 | 11.51 | 65 | 5.65 | 28,778 | 2,043,218 | |
| 13 | 2,332 | 12.27 | 70.3 | 5.73 | 41,087 | 95,794,311 | |
| 14 | 702 | 13.56 | 77.6 | 5.72 | 48,953 | 34,340,738 | |
| 15 | 7,848 | 14.48 | 83.5 | 5.77 | 51,974 | 407,867,168 | 28.9% |
| 16 | 1,429 | 15.49 | 89.6 | 5.78 | 50,984 | 72,830,328 | |
| 17 | 329 | 16.38 | 93.6 | 5.71 | 45,336 | 14,892,761 | |
| 18 | 52 | 17.4 | 95.3 | 5.48 | 31,527 | 1,623,655 | |
| 19 | 0 | 0 | 0 | 0.00 | 0 | 0 | |
| 20 | 0 | 0 | 0 | 0.00 | 0 | 0 | |
| 21 | 0 | 0 | 0 | 0.00 | 0 | 0 | |
| 22 | 5 | 21.29 | 121.3 | 5.70 | 29,197 | 131,388 | |
| 23 | 0 | 22.6 | 131.1 | 5.80 | 72,828 | 0 | |
| 24 | 20 | 23.37 | 136.6 | 5.85 | 37,241 | 726,196 | |
| 25 | 45 | 28.29 | 161.9 | 5.72 | 46,265 | 2,081,944 | |

**Table 5-8. Barge Trip Length Distribution, BPA Region**

| Trip Length (hrs) | Loaded Trips | Avg Hours | Avg Miles | Avg Speed (nautical mph) | Loaded Hrs | Trip Distribution % by Bin |
|---|---|---|---|---|---|---|
| 1 | 3,839 | 1.00 | 3.00 | 3.0 | 11,517 | 8.9% |
| 2 | 676 | 1.62 | 6.70 | 4.1 | 2,796 | 22.9% |
| 3 | 2,432 | 2.18 | 10.10 | 4.6 | 11,265 | |
| 4 | 3,100 | 3.20 | 16.20 | 5.1 | 15,694 | |
| 5 | 14,892 | 4.69 | 25.10 | 5.4 | 79,697 | 68.2%[29] |
| 6 | 1,575 | 5.69 | 31.20 | 5.5 | 8,636 | |
| 7 | 14 | 6.43 | 35.60 | 5.5 | 78 | |
| 8+ | 16 | 7.56 | 42.40 | 5.6 | 90 | |

Since the Houston-Galveston GIS network included the ICW from Freeport to Port Arthur (over 100 miles), and the channels extend over 50 miles inland on the Houston Ship Channel, this region had the longest transit trip times, with some trips being over 24 hours in length. Emission factor estimates were developed to match these trip lengths, as described in Section 5.3.

*Spatial Distribution*

The method of allocating activity levels (in product volumes by trip length bin) to specific counties uses GIS data to define inland waterways, which are then segmented with known latitude and longitude coordinates and distances in nautical miles. The VTS data contained origination and destination codes, which correspond to segments for GIS application. The channels for each port were assigned waypoints and channel segments. Routing for the determination of volume-hours was interpreted from VTS and port data so that ocean-going barge trips went out the ship channel to the Gulf of Mexico nine nautical miles to the state/federal boundary. Inland barge trips were assumed to constitute short shifts, termed "fleeting," or longer trips in the waterways of up to a day's length, called "line haul." Once routing was determined, barge traffic counts and associated product volumes were summed for each segment. The routes used for the study are presented for each region in Figures 5-1 through 5-3 below.

While the WCUS product volume data was grouped by study region (HGB, BPA, and Corpus Christi), volume data was also reported for the ICW. As such, internal movements of towboats and barges are reflected in the port data, while traffic on the ICW is reported

[29] Assigned to a 9 hour trip length bin, as discussed.

separately. For the purposes of this study, the ICW tonnages were allocated to each of the study areas by estimating the amount of ICW mileage within each study area on a percentage basis, as summarized in Table 5-9 below.

**Table 5-9. ICW Mileage Allocation by Region**

| Region | Nautical Miles | Fraction in Area |
|---|---|---|
| HGB | 90.78 | 0.588 |
| BPA | 25.07 | 0.162 |
| Corpus Christi | 38.64 | 0.250 |

The above approach provides a precise geographic allocation for determining the annual traffic volume on each segment, as well as the amount of time spent transiting that segment. Using a spreadsheet, each series of waterway segments was organized into towboat/barge trips. For example, a 60-mile trip along the ICW might be comprised of 20 segments of approximately 3 miles each. Spatial resolution was most resolved for the HGB area, using GIS information previously prepared for the Port Authority of Houston. In addition, the ICW region has been digitized in an ozone modeling effort currently being conducted for the TCEQ. The BPA and Corpus Christi area segments were digitized separately using a slightly coarser routing network, using GIS overlays from the US Army Corps of Engineers.

**Figure 5-1. HGB Region Barge Routes**

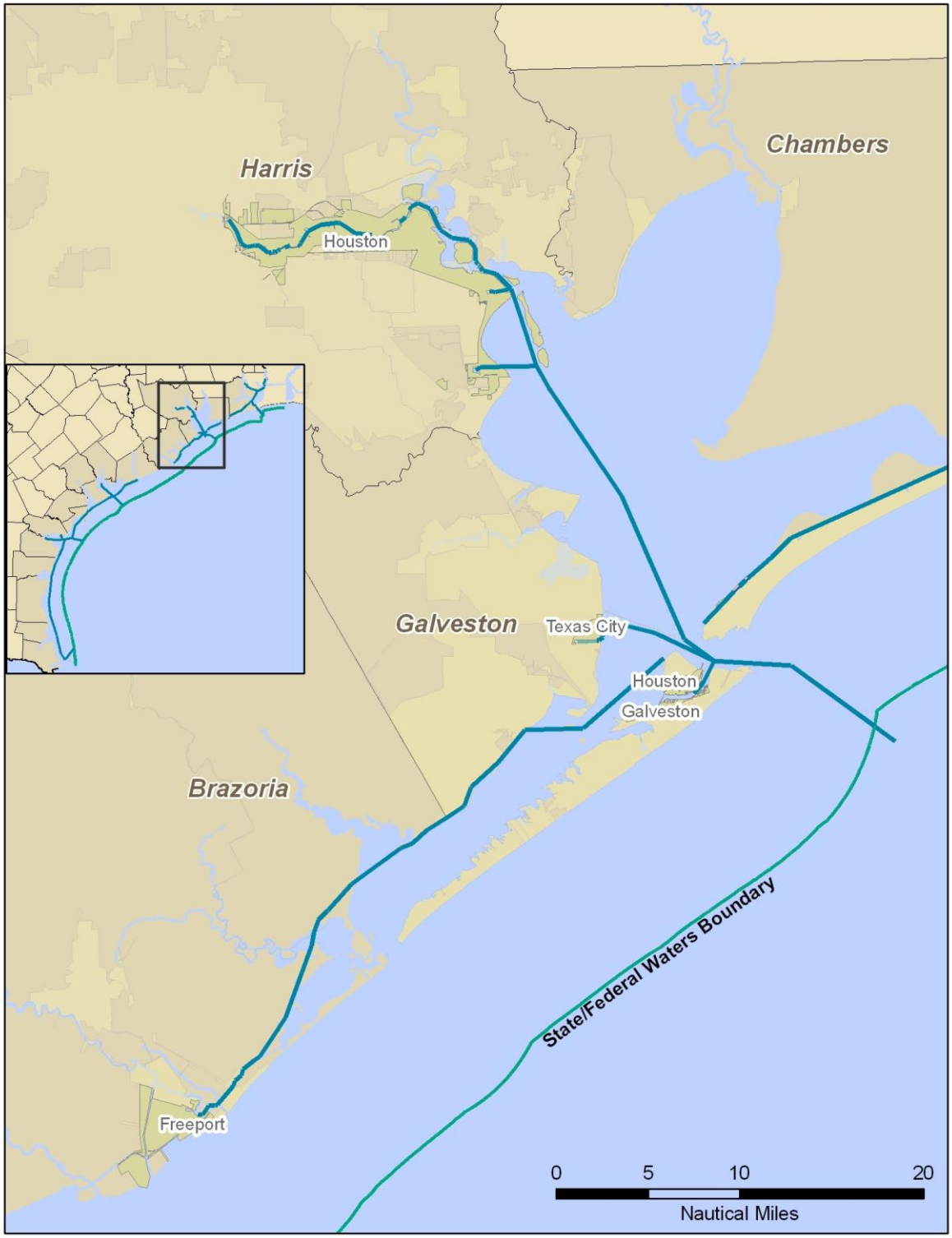


**Figure 5-2. BPA Region Barge Routes**

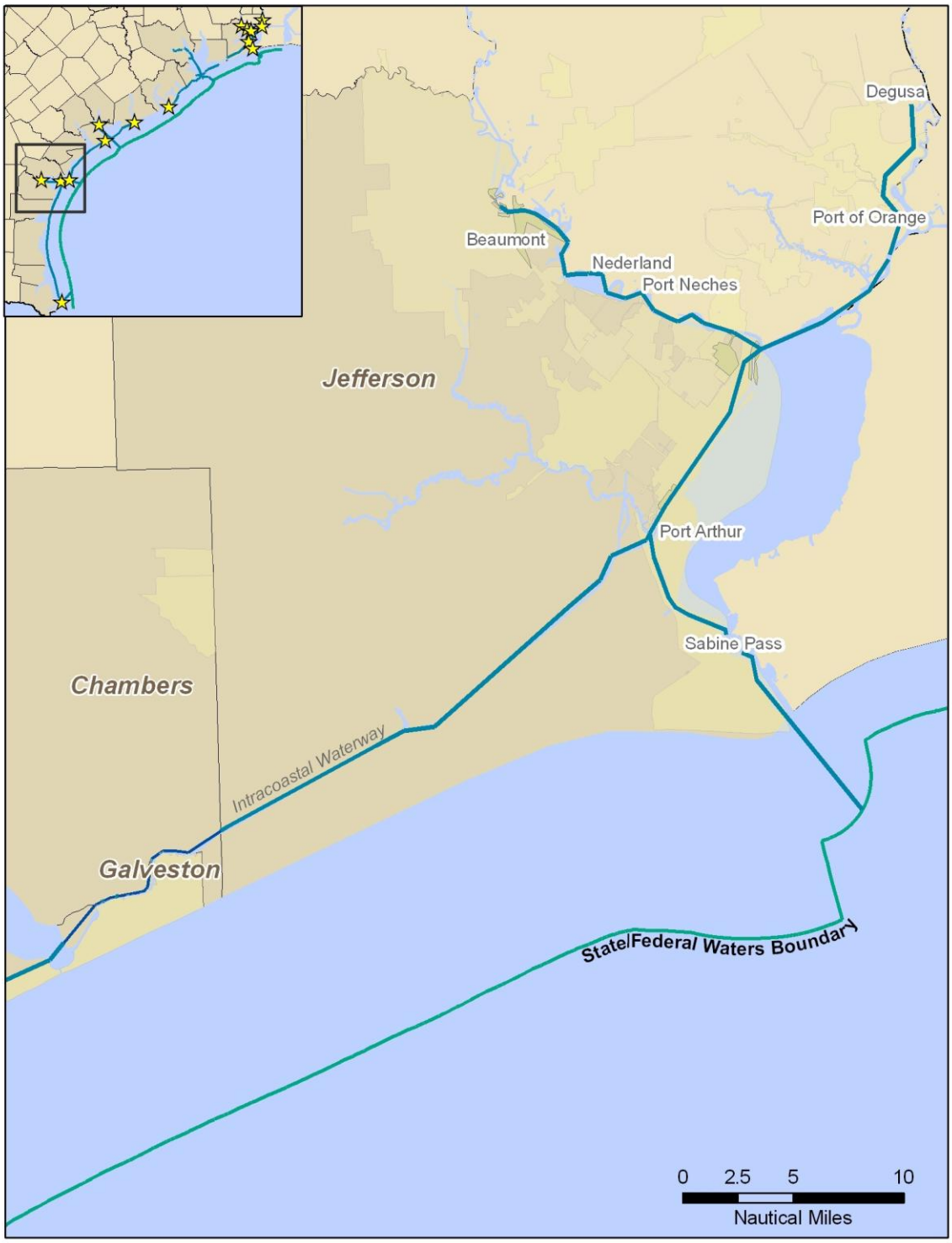


**Figure 5-3. Corpus Christi Region Barge Routes**

*Data Aggregation*

Once liquid barge product volumes and estimated trip durations were determined, the volumes of product were then allocated by commodity type such as gasoline, distillate, crude oil, and various chemicals, as indicated in Table 5-1. These product volumes were assumed to be delivered uniformly over each month of the year, except for gasoline deliveries which vary by season, as discussed in Section 5.2.

*Barge-to-Barge Transfers*

No data source was identified to quantify barge-to-barge liquid transfer activity, so this activity is not included in the final emission inventory.

## 5.5 Emission Inventory Development

*Scenario Processing*

As noted above, product activity data were excluded for four WCUS categories with essentially non-volatile products. In addition, base case modeling was only performed for 1 psi barges, as products placed in properly operating 3 and 6 psi barges were determined not to emit under any operating conditions.

As air temperature and solar insolation are the primary drivers for the TANKS equations, emissions were modeled for each month and each region separately. Data on day length by month was used in conjunction with the insolation and air temperature data to determine the number of hours across which these factors are applied.

Total product volumes for each region were then allocated into 12 discrete bins, one for each month of the year. Next, 33% of the remaining product volume for each category was removed from consideration for modeling to account for night time shipments. Then, the remaining product volume for each region and each month was divided into bins representing trip length, as determined from VTS routing data. These cargos were then proportionally allocated to barges of particular pressure ratings according to the guidelines supplied by industry representatives, to estimate the volumes assigned to 1 psi barges.

Empty barge trips were modeled similarly to full barges, with the following assumptions:

- the vapor space equals 99.9% of the cargo capacity of the barge;
- the vapor space temperature is equal to the ambient air temperature at the beginning of the trip; and

- the liquid temperature (heel) is equivalent to the average ambient air temperature.

A spreadsheet was developed to calculate the VOC emission factors associated with each scenario combination. Additional sensitivity analyses were also performed to estimate "uncontrolled" emission levels and other factors, as described in Section 6. The resulting emission factor tables were then combined with the activity data to estimate total VOC emissions by product type, trip length category, barge psi rating, month, and county. These totals were then summed to provide annual VOC emissions by county.

*VOC Speciation*

After development of the VOC emissions inventory, speciated emissions for the identified hazardous air pollutant (HAP) and highly reactive VOC (HRVOC) species were developed. These speciated emissions were generated by combining VOC emission estimates for each product type with appropriate speciation profiles. Speciation profiles identify the fractional weight percent of each relevant species compared to total VOC emissions. Speciation profiles were obtained from U.S. EPA's *SPECIATE* database and representative material safety data sheets (MSDS). Speciation was only determined for those products that were reasonably well defined; that is, speciation was not determined for product categories that were ambiguous or otherwise ill-defined (e.g., "other hydrocarbons", etc.).

*Post-Processing and Data Formatting*

Once calculated, VOC emission totals had to be formatted for use with the TCEQ's TEXAER data repository. The above methodology calculates barge transit emissions using a separate emission factor for each combination of commodity and barge pressure rating, and in some instances, by the time of year and region of the state (to account for changes in the formulation of gasoline). Therefore each unique combination of these characteristics may merit a separate Source Classification Code (SCC) for reporting emissions from this source category. However, the current list of available SCCs in the Emissions Inventory System Consolidated Emissions Reporting (EIS CER) code tables specific to storage and transport of petroleum and petroleum products and organic chemicals by marine vessels does not accommodate reporting emissions from barges in transit at this level of detail. In fact, only one SCC is provided for reporting emissions from barges, and is limited to gasoline (2505020121), as seen below. (3)

| SCC | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| 2505020121 | Storage and Transport | Petroleum and Petroleum Product Transport | Marine Vessel | Gasoline - Barge |

In order to report emissions from barges in transit as accurately as possible, the following SCCs have been proposed according to the descriptions provided in Table 5-10 below. All SCCs correspond to product transport in 1 psi barges. These SCCs can be loaded directly into the TEXAER system, although approval will be required before formal submissions can be made to the EPA.

**Table 5-10. Proposed Barge Transit Emission SCC Codes**

| Product | Proposed SCC |
|---|---|
| 2-ethylhexanol | 2515020008 |
| hexanol | 2515020007 |
| #1 diesel | 2505020091 |
| #2 diesel | 2505020092 |
| 1-heptene | 2515020003 |
| acetic acid | 2515020011 |
| benzene | 2515020382 |
| BPA Summer Gasoline | 2505020121 |
| BPA Winter Gasoline | 2505020121 |
| butanols (iso butyl alcohol) | 2515020060 |
| butyl acrylate | 2515020017 |
| butyric acid | 2515020013 |
| Corpus Summer Gasoline | 2505020121 |
| Corpus Winter Gasoline | 2505020121 |
| crude oil RVP 5 | 2505020030 |
| cumene | 2515020015 |
| decanol | 2515020006 |
| ethanol | 2515020165 |
| heptanes | 2515020001 |
| hexane | 2515020004 |
| HGB Summer Gasoline | 2505020121 |
| HGB Winter Gasoline | 2505020121 |
| isopropanol | 2515020250 |
| jet kerosene (Jet A) | 2505020182 |
| jet naphtha (JP-4) | 2505020150 |
| kerosene (fuel oil #1) | 2505020180 |
| Lube oil | 2505020041 |
| marine diesel oil | 2505020093 |
| MEK | 2515020275 |
| methanol | 2515020260 |
| MIBK | 2515020285 |
| MTBE | 2515020016 |

| Product | Proposed SCC |
|---|---|
| naphtha | 2515020370 |
| n-decane | 2515020002 |
| nonene | 2515020005 |
| propionic acid | 2515020012 |
| propyl acetate | 2515020019 |
| No. 6 fuel oil | 2505020060 |
| solvents (JP-4) | 2515020372 |
| styrene | 2515020014 |
| toluene | 2515020380 |
| vinyl acetate | 2515020018 |
| xylene | 2515020405 |

Emissions and activity data were reported for each new SCC proposed for this emissions source in NIF3.0 format, suitable for loading into TexAER. Where available, other supporting data were incorporated into the NIF3.0 data files.

# 6.0 Results and Discussion

Details regarding barge transit activity, emission factors, and mass emission estimates are provided in the following section.

## 6.1 Activity Data

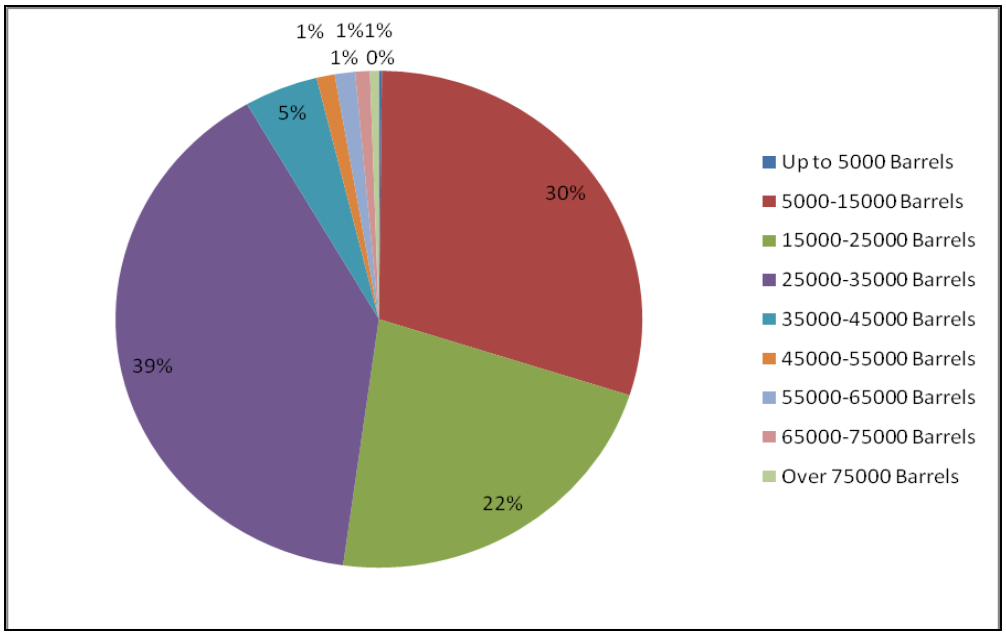
The VTS barge activity and the WCUS product volume data provide the basis for characterizing barge transit activity levels for the emission inventory. Key information regarding trip length distributions, the prevalence of loaded versus empty trips, and barge routes has been provided in Section 5. Additional descriptive statistics are provided below regarding barge sizes and product volumes.

*Barge Size Distribution*

The VTS data for the HGB area provided detailed information on barge dimensions, which were used to estimate approximate barge capacity volumes (assuming volume = length x width x height). Figure 6-1 summarizes the fraction of barge trips made by different sized barges in the region. As seen, over 90 percent of all trips are made by barges 35,000 barrels in size and smaller, representing inland tank barges, with the remainder of trips likely attributable to articulated/integrated ocean-going bares.[30] Comparable information was not available for the other two study areas.

[30] The VTS dimension data for the HGB area does not always clearly distinguish between single and multiple barges in a tow string. Accordingly, some unknown number of barges > 35,000 bbl may in fact represent multiple, smaller barges. As such, Figure 1 is provided as a general reference for characterizing the tank barge fleet, and is not used in estimating actual VOC transit emissions.

**Figure 6-1. Barge Size Distribution, HGB Region**




*Product Volumes by Study Region*

WCUS data provide estimated shipment tonnage by general product category. In consultation with industry representatives, product distributions were developed to represent each WCUS product category, as indicated in Table 5.1. Densities for these products were obtained from Perry's Chemical Engineer's Handbook, and average values were calculated for each WCUS category using the relative product weights, as shown in Table 6-1.

## Table 6-1. WCUS Product Category Densities (lb/gal) [31]

| WCUS Category | Specific Products | Liquid Density (lb/gal)* | Fraction by WCUS Category | Weighted Average Density |
|---|---|---|---|---|
| Acyclic Hydrocarbons | heptanes | 5.73 | 0.20 | 5.86 |
| Acyclic Hydrocarbons | n-decane | 6.09 | 0.20 | |
| Acyclic Hydrocarbons | 1-heptene | 5.81^ | 0.20 | |
| Acyclic Hydrocarbons | hexane | 5.53 | 0.20 | |
| Acyclic Hydrocarbons | nonene | 6.16^ | 0.20 | |
| Alcohols | methanol | 6.63 | 0.14 | 7.07 |
| Alcohols | ethanol | 6.61 | 0.14 | |
| Alcohols | isopropanol | 6.57 | 0.14 | |
| Alcohols | butanols (iso butyl alcohol) | 6.71 | 0.14 | |
| Alcohols | decanol | 8.93 | 0.14 | |
| Alcohols | hexanol | 7.09^ | 0.14 | |
| Alcohols | 2-ethylhexanol | 6.96^ | 0.14 | |
| Benzene/Toluene | benzene | 7.37 | 0.50 | 7.31 |
| Benzene/Toluene | toluene | 7.26 | 0.50 | |
| Carboxylic Acids | acetic acid | 8.76 | 0.33 | 8.35 |
| Carboxylic Acids | propionic acid | 8.30^ | 0.33 | |
| Carboxylic Acids | butyric acid | 8.01 | 0.33 | |
| Crude Oil | crude oil RVP 5 | 7.10 | 1.00 | 7.10 |
| Distillate Fuel Oils | #1 diesel | 6.74 | 0.33 | 7.00 |
| Distillate Fuel Oils | #2 diesel | 7.10 | 0.33 | |
| Distillate Fuel Oils | marine diesel oil | 7.17 | 0.33 | |
| Gasoline | HGB Summer Gasoline | 5.60 | 0.50 | 5.60 |
| Gasoline | HGB Winter Gasoline | 5.60 | 0.50 | |
| Gasoline | BPA Summer Gasoline | 5.60 | 0.50 | 5.60 |
| Gasoline | BPA Winter Gasoline | 5.60 | 0.50 | |
| Gasoline | Corpus Summer Gasoline | 5.60 | 0.50 | 5.60 |
| Gasoline | Corpus Winter Gasoline | 5.60 | 0.50 | |
| Kerosene | kerosene (fuel oil #1) | 7.01 | 0.33 | 6.80 |
| Kerosene | jet kerosene (Jet A) | 7.00 | 0.33 | |
| Kerosene | jet naphtha (JP-4) | 6.40 | 0.33 | |
| Naptha/Solvents | naphtha | 6.26 | 0.50 | 6.33 |
| Naptha/Solvents | solvents (JP-4) | 6.40 | 0.50 | |
| Other Hydrocarbons | styrene | 7.56 | 0.11 | 7.08 |
| Other Hydrocarbons | cumene | 7.19 | 0.11 | |
| Other Hydrocarbons | MEK | 6.75 | 0.11 | |

[31] Density at 60 degrees F, unless noted (^ at 68 degrees)

| WCUS Category | Specific Products | Liquid Density (lb/gal)* | Fraction by WCUS Category | Weighted Average Density |
|---|---|---|---|---|
| Other Hydrocarbons | MTBE | 6.17 | 0.11 | |
| Other Hydrocarbons | butyl acrylate | 7.42 | 0.11 | |
| Other Hydrocarbons | vinyl acetate | 7.82 | 0.11 | |
| Other Hydrocarbons | xylene | 7.17 | 0.11 | |
| Other Hydrocarbons | propyl acetate | 6.97 | 0.11 | |
| Other Hydrocarbons | MIBK | 6.69 | 0.11 | |
| Petroleum Products NEC | lube oil | 7.51 | 1.00 | 7.51 |
| Residual Fuel Oil | No. 6 fuel oil | 7.90 | 1.00 | 7.90 |

The above weighted average product densities were combined with the WCUS product tonnage data to provide product volumes by study region, as summarized in Figures 6-2 through 6-4. In all cases, gasoline, distillate fuel oil, residual fuel oil, and crude oil dominate the distributions, with notable contributions from Other Hydrocarbons, Petroleum Products NEC, and Benzene/Toluene.

**Figure 6-2. WCUS Product Volumes, HGB Region (%)**

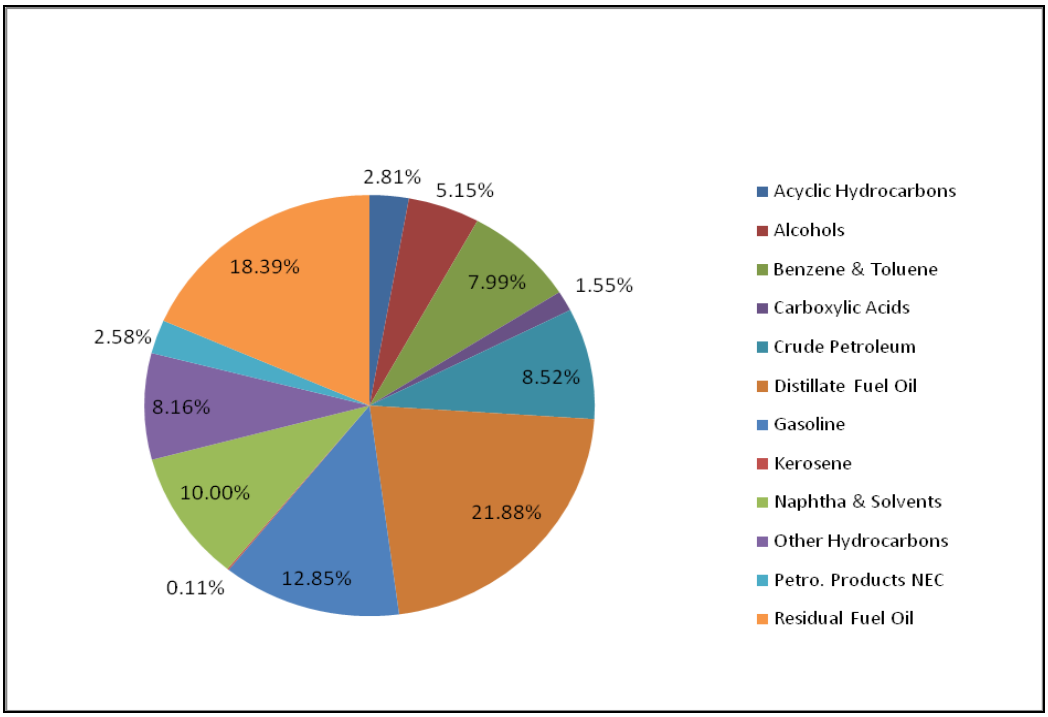



**Figure 6-3. WCUS Product Volumes, BPA Region (%)**

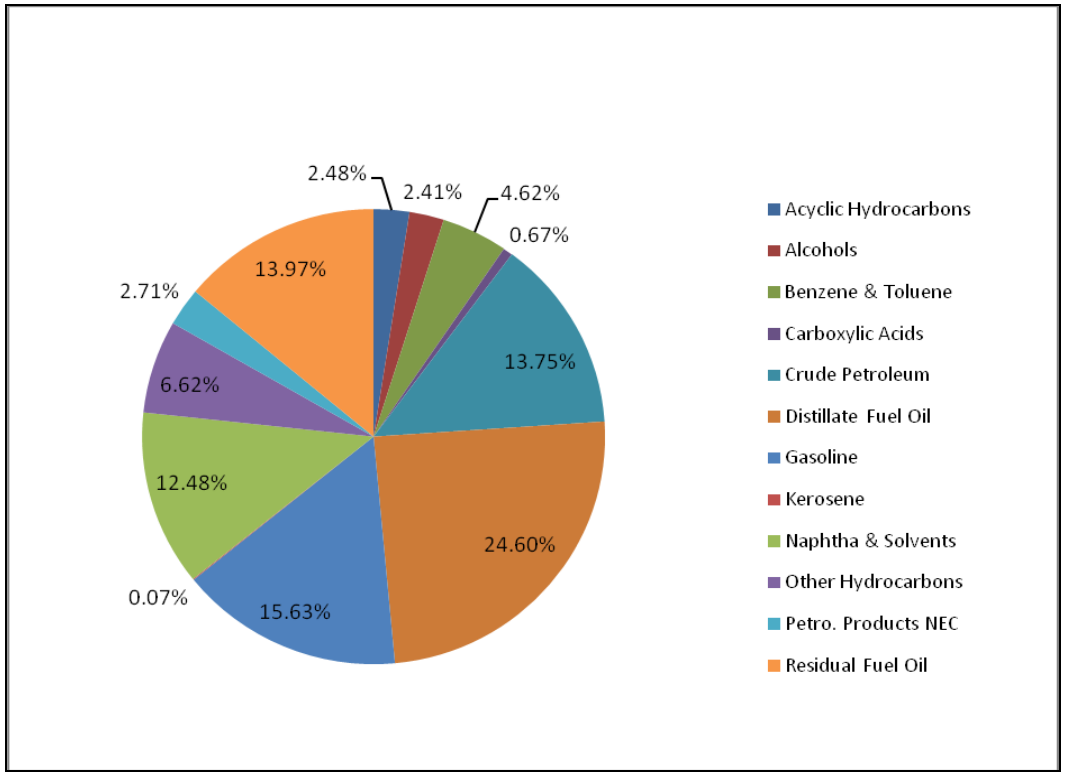
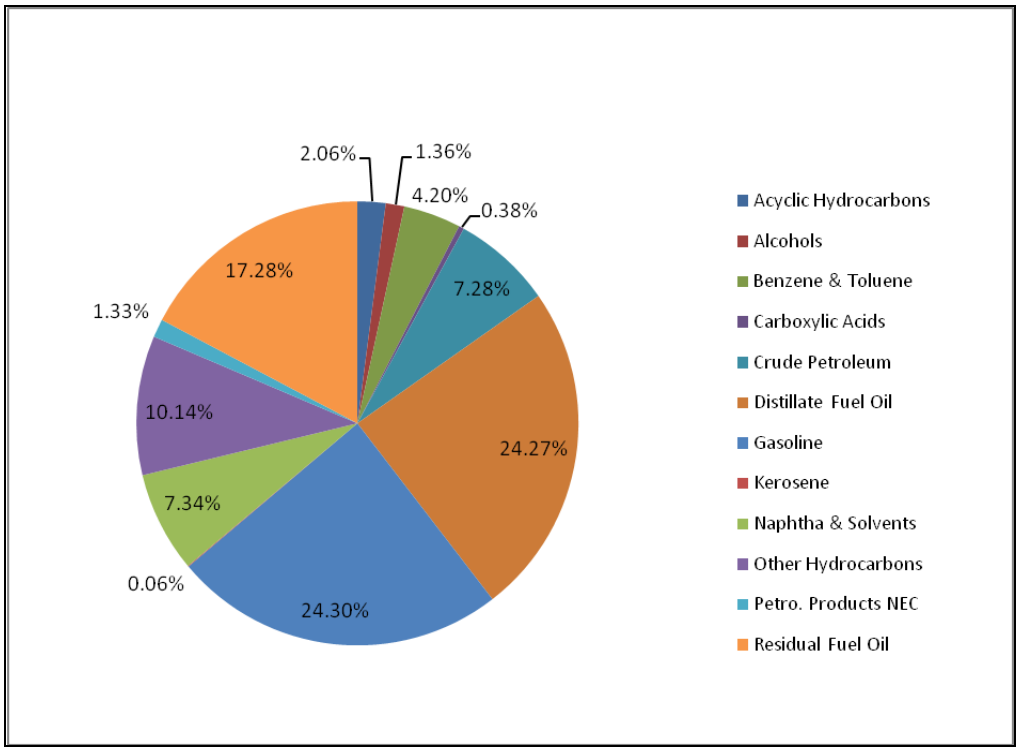


**Figure 6-4. WCUS Product Volumes, Corpus Christi Region (%)**




## 6.2 Base Case Inventory Findings

As discussed in Section 5.2, the API calculation method for low pressure tanks was used as a screening tool to determine which product type/barge psi rating combinations are not expected to have transit VOC emissions under any normal operating condition. Based on this analysis it was concluded that 3 psi and 6 psi barges would not release VOC emissions when operated correctly. Table 6-2 summarizes the screening results, based on the product allocation rules specified by industry representatives. Products expected to have emissions are highlighted. See Appendix B for detailed findings regarding maximum internal tank pressure increases by product type, region, and month.

## Table 6-2. API Pressure Calculation Screening Results

| WCUS Product Group | Specific Products | Vap Pres at 100 deg. F (psi) | % Shipped in 1 psi barge | % Shipped in 3 psi barge | % Shipped in 6 psi barge | Model Base Case Emissions ? |
|---|---|---|---|---|---|---|
| Acyclic Hydrocarbons | heptanes | 1.586 | 30% | 70% | 0% | YES |
| | n-decane | 0.083 | 100% | 0% | 0% | YES |
| | 1-heptene | 1.953 | 30% | 70% | 0% | YES |
| | hexane | 4.892 | 0% | 95% | 5% | NO |
| | nonene | 0.179 | 100% | 0% | 0% | YES |
| Alcohols | methanol | 4.525 | 0% | 95% | 5% | NO |
| | ethanol | 2.320 | 30% | 70% | 0% | YES |
| | isopropanol | 1.779 | 30% | 70% | 0% | YES |
| | butanols (iso butyl alcohol) | 0.541 | 100% | 0% | 0% | YES |
| | decanol | 0.000 | 100% | 0% | 0% | YES |
| | hexanol | 0.027 | 100% | 0% | 0% | YES |
| | 2-ethylhexanol | 0.019 | 100% | 0% | 0% | YES |
| Benzene/Toluene | benzene | 3.287 | 10% | 85% | 5% | YES |
| | toluene | 1.006 | 30% | 70% | 0% | YES |
| Carboxylic Acids | acetic acid | 0.503 | 100% | 0% | 0% | YES |
| | propionic acid | 0.080 | 100% | 0% | 0% | YES |
| | butyric acid | 0.023 | 100% | 0% | 0% | YES |
| Chemical Products NEC | Assume non-volatile | N/A | 0% | 0% | 0% | NO |
| Chemical Additives | Assume non-volatile | N/A | 0% | 0% | 0% | NO |
| Crude Petroleum | crude oil RVP 5 | 5.70 | 0% | 95% | 5% | NO |
| Distillate Fuel Oils | #1 diesel | 0.097 | 100% | 0% | 0% | YES |
| | #2 diesel | 0.022 | 100% | 0% | 0% | YES |
| | marine diesel oil | 0.022 | 100% | 0% | 0% | YES |
| Gasoline | HGB Summer Gasoline | 5.800 | 25% | 85% | 5% | YES |
| | HGB Winter Gasoline | 10.900 | 25% | 85% | 5% | YES |
| | BPA Summer Gasoline | 6.100 | 25% | 85% | 5% | YES |
| | BPA Winter Gasoline | 12.200 | 25% | 85% | 5% | YES |
| | Corpus Summer Gasoline | 7.500 | 25% | 85% | 5% | YES |
| | Corpus Winter Gasoline | 12.400 | 25% | 85% | 5% | YES |
| Kerosene | kerosene (fuel oil #1) | 0.100 | 100% | 0% | 0% | YES |
| | jet kerosene (Jet A) | 0.029 | 100% | 0% | 0% | YES |
| | jet naphtha (JP-4) | 2.700 | 30% | 70% | 0% | YES |
| Naphtha and Solvents | naphtha | 0.266 | 100% | 0% | 0% | YES |
| | solvents (JP-4 basis) | 2.700 | 30% | 70% | 0% | YES |
| Organic Compounds NEC | Assume non-volatile | N/A | 0% | 0% | 0% | NO |
| Organo-Inorganic Cmpds | Assume non-volatile | N/A | 0% | 0% | 0% | NO |
| Other Hydrocarbons | styrene | 0.508 | 100% | 0% | 0% | YES |
| | cumene | 0.190 | 100% | 0% | 0% | YES |
| | MEK | 3.345 | 0% | 95% | 5% | NO |
| | MTBE | 9.261 | 0% | 95% | 5% | NO |
| | butyl acrylate | 0.123 | 100% | 0% | 0% | YES |
| | vinyl acetate | 4.022 | 0% | 95% | 5% | NO |
| | xylene | 0.342 | 100% | 0% | 0% | YES |
| | propyl acetate | 1.000 | 30% | 70% | 0% | YES |
| | MIBK | 0.360 | 100% | 0% | 0% | YES |
| Petroleum Products NEC | lube oil | 0.001 | 100% | 0% | 0% | YES |
| Residual Fuel Oil | No. 6 fuel oil | 0.019 | 100% | 0% | 0% | YES |

Accordingly, emission factors for each product type highlighted above were developed for 1 psi barges using the TANKS model equations. The emission factors, calculated using Equation 9 in Section 5, are expressed in pounds of VOC emissions per barrel of product transported. The factors are specific to each product type/month/region/trip length bin, and are presented in Appendix E.

Emission factors for the BPA and Corpus Christi regions were adjusted to account for barge and vapor space heating occurring outside these areas. For example, the emission factors developed for the longest BPA trip length bin correspond to 9 hours worth of emissions, although these barges only spend 6 of these hours in the BPA region proper. Therefore these factors were adjusted downward by a factor of 6/9, or two thirds. For the Corpus Christi area it was assumed that 50 percent of all trips originate and leave the area in 5 hours, although the TANKS model equations indicate that 5 hour trips do not absorb enough heat to generate emissions. The remaining 50 percent of inbound trips were assumed to be "pre-heated" outside of the area. Similar to the BPA adjustment, the emission factors for the inbound barges were adjusted to reflect the fraction of total daytime heating that occurred in the Corpus region. For example, in June there are 13.9 hours of daylight in the region, so emission factors estimated for a day long trip are adjusted by 5/13.9, or about one third.

Table 6-3 presents the calendar year 2008 annual VOC emission estimates for barge transit activity, by product and study region. Table 6-4 provides VOC totals summed across all products by county.

**Table 6-3. Annual VOC Barge Transit Emissions by Product Type and Study Region, Base Case 2008 (Tons/Year)**

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| Acyclic Hydrocarbons | heptanes | 0.2967 | 0.0382 | 0.0873 |
| | n-decane | 0.0519 | 0.0000 | 0.0221 |
| | 1-heptene | 0.3212 | 0.0419 | 0.0915 |
| | hexane | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.1050 | 0.0000 | 0.0484 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.3261 | 0.0319 | 0.0296 |
| | isopropanol | 0.2972 | 0.0253 | 0.0288 |
| | butanols (iso butyl alcohol) | 0.2667 | 0.0076 | 0.0337 |
| | decanol | 0.0003 | 0.0000 | 0.0000 |
| | hexanol | 0.0651 | 0.0000 | 0.0100 |
| | 2-ethylhexanol | 0.0131 | 0.0000 | 0.0021 |
| Benzene/Toluene | benzene | 1.5409 | 0.2183 | 0.2601 |

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| | toluene | 1.1523 | 0.0739 | 0.2616 |
| Carboxylic Acids | acetic acid | 0.1749 | 0.0036 | 0.0205 |
| | propionic acid | 0.0540 | 0.0000 | 0.0074 |
| | butyric acid | 0.0183 | 0.0000 | 0.0026 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.9372 | 0.0000 | 0.6110 |
| | #2 diesel | 0.1493 | 0.0000 | 0.1006 |
| | marine diesel oil | 0.1493 | 0.0000 | 0.1006 |
| Gasoline | HGB Summer Gasoline | 8.9248 | 0.0000 | 0.0000 |
| | HGB Winter Gasoline | 4.9254 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline | 0.0000 | 2.8158 | 0.0000 |
| | BPA Winter Gasoline | 0.0000 | 2.3870 | 0.0000 |
| | Corpus Summer Gasoline | 0.0000 | 0.0000 | 6.8404 |
| | Corpus Winter Gasoline | 0.0000 | 0.0000 | 4.2200 |
| Kerosene | kerosene (fuel oil #1) | 0.0047 | 0.0000 | 0.0015 |
| | jet kerosene (Jet A) | 0.0010 | 0.0000 | 0.0003 |
| | jet naphtha (JP-4) | 0.0291 | 0.0039 | 0.0057 |
| Naphtha and Solvents | naphtha | 1.1796 | 0.0000 | 0.5342 |
| | solvents (JP-4) | 3.9004 | 1.0273 | 1.0352 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | styrene | 0.2231 | 0.0007 | 0.1502 |
| | cumene | 0.1648 | 0.0005 | 0.1130 |
| | MEK | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 |
| | butyl acrylate | 0.2027 | 0.0002 | 0.1385 |
| | vinyl acetate | 0.0000 | 0.0000 | 0.0000 |
| | xylene | 0.2766 | 0.0053 | 0.1769 |
| | propyl acetate | 0.3609 | 0.0338 | 0.1857 |
| | MIBK | 0.2473 | 0.0041 | 0.1581 |
| Petroleum Products NEC | lube oil | 0.0021 | 0.0000 | 0.0007 |
| Residual Fuel Oil | No. 6 fuel oil | 0.0044 | 0.0000 | 0.0025 |
| | ***Total*** | ***26.3665*** | ***6.7195*** | ***15.2807*** |

**Table 6-4. Annual VOC Barge Transit Emissions by County, Base Case 2008 (Tons/Year)**

| County | Tons/Year |
|---|---|
| Aransas | 0.14 |
| Brazoria | 2.54 |
| Chambers | 2.80 |
| Galveston | 5.40 |
| Harris | 13.40 |
| Jefferson | 7.96 |
| Nueces | 8.44 |
| Orange | 1.00 |
| San Patricio | 6.70 |
| **Total** | **48.38** |

When comparing emission totals across regions, the emission totals for the HGB area are surprisingly low compared to the Corpus Christi area, considering total product volumes. This is largely due to the preponderance of relatively short trips that occur in the HGB region compared to Corpus Christi.

Table 6-5 breaks out the annual VOC totals for loaded and empty barges.

**Table 6-5. Annual VOC Barge Transit Emissions by Region, Loaded and Empty Trips 2008 (Tons/Year)**

| **Houston-Galveston-Brazoria** | | | | |
|---|---|---|---|---|
| **Trip Length** | **2-Hour** | **9-Hour** | **16-Hour** | **Total** |
| **Loaded** | 0.00 | 0.25 | 1.24 | 1.49 |
| **Empty** | 0.00 | 3.85 | 21.03 | 24.88 |
| **Beaumont/Port Arthur** | | | | |
| **Trip Length** | **1-Hour** | **3-Hour** | **6-Hour** | **Total** |
| **Loaded** | 0.00 | 0.00 | 0.56 | 0.56 |
| **Empty** | 0.00 | 0.00 | 6.16 | 6.16 |
| **Corpus Christi** | | | | |
| **Trip Length** | | | **5-Hour** | **Total** |
| **Loaded** | | | 1.49 | 1.49 |
| **Empty** | | | 13.79 | 13.79 |

VOC totals were speciated using EPA's SPECIATE database for those WCUS categories containing blends of compounds (i.e., naptha, gasoline, crude oil, and distillate fuel oil) as opposed to pure products (e.g., benzene). (4) The following SPECIATE profiles were used:

- Crude Petroleum – composite SPECIATE profile for crude oil storage tanks;

- Distillate Fuel Oil - Speciated using an average profile derived from 6 SPECIATE profiles for diesel headspace vapor. #1 diesel, #2 diesel, and marine diesel oil were summed together;
- Gasoline - Speciated using SPECIATE composite profile for ethanol blended gasoline headspace vapor. A number of Texas-specific profiles were not used because they were circa 2000 MTBE blended headspace profiles. Summer and winter gasolines were summed together;
- Naptha - Speciated using an average profile derived from 8 SPECIATE profiles for naphtha;
- Solvents - Speciated using an average profile derived from 10 SPECIATE profiles for mineral spirits and Stoddard solvent.

Tables 6-6 and 6-7 present the annual HAP and HRVOC totals for these product categories, by study region.

**Table 6-6. Annual HAP Barge Transit Emissions by Study Region, Base Case 2008 (Tons/Year)**

| HAP Emission Totals (Tons/Year) | | | | |
|---|---|---|---|---|
| **Species Name** | **CAS #** | **HGB** | **BPA** | **Corpus** |
| **2,2,4-trimethylpentane** | **540-84-1** | 0.7649 | 0.2820 | 0.6008 |
| **benzene** | **71-43-2** | 1.7092 | 0.2786 | 0.3935 |
| **ethylbenzene** | **100-41-4** | 0.0751 | 0.0186 | 0.0546 |
| **isopropylbenzene (cumene)** | **98-82-8** | 0.0133 | 0.0029 | 0.0063 |
| **m & p-xylene** | **108-38-3; 106-42-3** | 0.1617 | 0.0360 | 0.1198 |
| **m-xylene** | **108-38-3** | 0.0316 | 0.0013 | 0.0134 |
| **n-hexane** | **110-54-3** | 0.3599 | 0.1282 | 0.2848 |
| **naphthalene** | **91-20-3** | 0.0051 | 0.0011 | 0.0030 |
| **o-xylene** | **95-47-6** | 0.0626 | 0.0127 | 0.0411 |
| **p-xylene** | **106-42-3** | 0.0109 | 0.0004 | 0.0046 |
| **styrene** | **100-42-5** | 0.2231 | 0.0007 | 0.1502 |
| **toluene** | **108-88-3** | 1.8235 | 0.3148 | 0.7923 |
| **xylene (mixed isomers)** | **N/A** | 0.2766 | 0.0053 | 0.1769 |
| | ***Total:*** | ***5.5175*** | ***1.0826*** | ***2.6413*** |

**Table 6-7. Annual HRVOC Barge Transit Emissions by Study Region, Base Case 2008 (Tons/Year)**

| HRVOC Emission Totals - Tons/Year | | | | |
|---|---|---|---|---|
| **Species Name** | **CAS #** | **HGB** | **BPA** | **Corpus** |
| **1-butene** | **106-98-9** | 0.0289 | 0.0081 | 0.0221 |
| **isobutylene (isobutene)** | **115-11-7** | 0.0269 | 0.0085 | 0.0209 |
| **propylene** | **115-07-1** | 0.0050 | 0.0000 | 0.0033 |
| | ***Total:*** | ***0.0609*** | ***0.0166*** | ***0.0463*** |

## 6.3 Analysis Uncertainties

A number of uncertainties have been identified associated with the data inputs and emission calculation methods described above.

*Activity Inputs*

Uncertainties associated with activity inputs include the following:

- The WCUS product volumes rely on self-reporting by barge operators, and are therefore subject to some error, both in terms of total barrels as well as product category classifications. The net impact of reporting uncertainties is unknown. In addition, the WCUS does not capture foreign vessel product movements, which occur with an unspecified frequency on the ICW, and would tend to cause an under-estimation of emissions to some degree.
- Effective trip lengths may be longer than estimated, for two reasons. First, the analysis assumes that pressure equalization occurs between the barge and the atmosphere at the end of each "trip". However, as noted above many barges may engage in fleeting operations where the barge is temporarily stored in a location without loading or unloading product before the next "trip". Second, some unknown number of trips may originate or terminate at distant locations such as New Orleans or Mexico. As such, these trips could entail multiple heating cycles, although they have been segmented into shorter trips for this assessment. Based on these factors, the emissions may be under-estimated to some degree.
- AIS time stamps were not available for this study. As such, the fraction of product movement at night (assumed to be one third of the WCUS total) is not known.
- Aside from the variation for winter and summer gasolines, seasonal variability in product volumes is not known.
- Barge volumes are not known for the Corpus Christi region, and are assumed to be equivalent to the other regions with VTS data.

*Emission Factors*

Uncertainties associated with emission factors and mass emissions include the following:

- Liquid product and vapor space temperatures are uncertain for a number of reasons. First, the associated ambient air temperatures used in the analyses are based on 30 year averages, and can vary significantly on a day to day basis, with cooler days lowering emission rates, and warmer days raising emission rates. Similarly, solar insolation levels will vary depending upon cloud cover. Solar absorptance values vary as well, depending upon barge colors and paint conditions. In addition, around 10% of the current barge fleet still features single hulls, which may allow for significant heat transfer between the outside water and the liquid product. Finally, the emission estimation methodology makes a simplifying assumption that temperatures rise linearly over the full length of the

day, while daily temperature peaks usually occur a few hours before sunset. The net impact of this assumption is unknown, however, since trip distributions as a function of time of day are not known.

- Vapor pressures are subject to uncertainty for two reasons. First, to the extent that liquid surface temperatures are uncertain, product vapor pressures will also be uncertain. Second, as discussed earlier, the specific compounds and their relative amounts within each WCUS product category are highly uncertain. For this reason, VOC, HAP, and HRVOC speciation factors are also uncertain.
- Industry representatives provided general guidelines for assigning product types to 1, 3, and 6 psi barges. However, the actual allocation ratios are not known.
- The TANKS model equations are intended to estimate breathing loss emissions under atmospheric rather than low pressure conditions (i.e., 1 psi barges for the base case modeling scenario).
- Finally, the base case controlled emission scenario assumes that all barges have properly operating pressure valves and containment systems. While the frequency of malfunctioning valves or "gross emitters" is unknown, their presence will clearly increase actual emission rates.

## 6.4 Sensitivity Analyses

While the net effect of the above uncertainties is unknown, sensitivity analyses were conducted to estimate the relative importance of several of these factors on mass emissions estimates. First, uncontrolled emissions were estimated by assigning 100 percent of barge product volumes to 1 psi barges. Emissions were calculated using this scenario for all "daytime" product volumes (i.e., two thirds of all product transports). Table 6-8 presents the annual uncontrolled VOC emission estimates by product and study region. These totals indicate an approximately 83 percent control effectiveness for barge transit VOC emissions, given the assumptions described in Section 5. The table indicates that emission estimates are highly sensitive to product/barge psi assignments.

**Table 6-8 Annual "Uncontrolled" VOC Barge Transit Emissions by Product Type and Region, 2008 (Tons/Year)**

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| Acyclic Hydrocarbons | heptanes | 0.9891 | 0.1274 | 0.2910 |
| | n-decane | 0.0519 | 0.0000 | 0.0221 |
| | 1-heptene | 1.0705 | 0.1398 | 0.3050 |
| | hexane | 3.9007 | 0.9096 | 0.8662 |
| | nonene | 0.1050 | 0.0000 | 0.0484 |
| Alcohols | methanol | 1.9027 | 0.2396 | 0.1491 |
| | ethanol | 1.0870 | 0.1065 | 0.0987 |
| | isopropanol | 0.9906 | 0.0843 | 0.0959 |

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| | butanols (iso butyl alcohol) | 0.2667 | 0.0076 | 0.0337 |
| | decanol | 0.0003 | 0.0000 | 0.0000 |
| | hexanol | 0.0651 | 0.0000 | 0.0100 |
| | 2-ethylhexanol | 0.0131 | 0.0000 | 0.0021 |
| Benzene/Toluene | benzene | 15.4086 | 2.1835 | 2.6015 |
| | toluene | 3.8411 | 0.2464 | 0.8718 |
| Carboxylic Acids | acetic acid | 0.1749 | 0.0036 | 0.0205 |
| | propionic acid | 0.0540 | 0.0000 | 0.0074 |
| | butyric acid | 0.0183 | 0.0000 | 0.0026 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 32.4893 | 12.3174 | 9.0333 |
| Distillate Fuel Oils | #1 diesel | 0.9372 | 0.0000 | 0.6110 |
| | #2 diesel | 0.1493 | 0.0000 | 0.1006 |
| | marine diesel oil | 0.1493 | 0.0000 | 0.1006 |
| Gasoline | HGB Summer Gasoline | 35.6992 | 0.0000 | 0.0000 |
| | HGB Winter Gasoline | 19.7018 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline | 0.0000 | 11.2633 | 0.0000 |
| | BPA Winter Gasoline | 0.0000 | 9.5482 | 0.0000 |
| | Corpus Summer Gasoline | 0.0000 | 0.0000 | 27.3616 |
| | Corpus Winter Gasoline | 0.0000 | 0.0000 | 16.8799 |
| Kerosene | kerosene (fuel oil #1) | 0.0047 | 0.0000 | 0.0015 |
| | jet kerosene (Jet A) | 0.0010 | 0.0000 | 0.0003 |
| | jet naphtha (JP-4) | 0.0969 | 0.0129 | 0.0191 |
| Naphtha and Solvents | naphtha | 1.1796 | 0.0000 | 0.5342 |
| | solvents (JP-4) | 13.0015 | 3.4244 | 3.4508 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | styrene | 0.2231 | 0.0007 | 0.1502 |
| | cumene | 0.1648 | 0.0005 | 0.1130 |
| | MEK | 3.2603 | 0.6524 | 1.2977 |
| | MTBE | 18.9772 | 4.7805 | 6.2900 |
| | butyl acrylate | 0.2027 | 0.0002 | 0.1385 |
| | vinyl acetate | 5.4858 | 1.1988 | 2.0358 |
| | xylene | 0.2766 | 0.0053 | 0.1769 |
| | propyl acetate | 1.2029 | 0.1128 | 0.6189 |
| | MIBK | 0.2473 | 0.0041 | 0.1581 |
| Petroleum Products NEC | lube oil | 0.0021 | 0.0000 | 0.0007 |
| Residual Fuel Oil | No. 6 fuel oil | 0.0044 | 0.0000 | 0.0025 |
| | ***Total*** | **163.3967** | **47.3696** | **74.5013** |

Emission factors also vary greatly depending upon trip length. In order to provide an upper bound on trip length impacts, an additional modeling scenario was developed assuming that all trips made under the base case required the maximum amount of time for a given region (e.g., 16 hours for HGB and 6 hours for BPA).[32] Table 6-9 presents the annual emission estimates assuming maximum trip length durations. In this case VOC emissions were estimated to increase by a factor of 3.7 for HGB and 1.7 for BPA, relative to the base case inventory.

**Table 6-9. Annual VOC Barge Transit Emissions by Product Type and Region, Maximum Trip Length Scenario, 2008 (Tons/Year)**

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| Acyclic Hydrocarbons | heptanes | 1.2174 | 0.0650 | 0.0873 |
| | n-decane | 0.2975 | 0.0000 | 0.0221 |
| | 1-heptene | 1.2753 | 0.0713 | 0.0915 |
| | hexane | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.6838 | 0.0000 | 0.0484 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 1.1490 | 0.0543 | 0.0296 |
| | isopropanol | 1.1099 | 0.0430 | 0.0288 |
| | butanols (iso butyl alcohol) | 1.2642 | 0.0128 | 0.0337 |
| | decanol | 0.0015 | 0.0000 | 0.0000 |
| | hexanol | 0.3726 | 0.0000 | 0.0100 |
| | 2-ethylhexanol | 0.0764 | 0.0000 | 0.0021 |
| Benzene/Toluene | benzene | 5.1747 | 0.3711 | 0.2601 |
| | toluene | 5.0495 | 0.1256 | 0.2616 |
| Carboxylic Acids | acetic acid | 0.8274 | 0.0061 | 0.0205 |
| | propionic acid | 0.2951 | 0.0000 | 0.0074 |
| | butyric acid | 0.0991 | 0.0000 | 0.0026 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 5.3967 | 0.0000 | 0.6110 |
| | #2 diesel | 0.8854 | 0.0000 | 0.1006 |
| | marine diesel oil | 0.8854 | 0.0000 | 0.1006 |
| Gasoline | HGB Summer Gasoline | 25.8979 | 0.0000 | 0.0000 |
| | HGB Winter Gasoline | 13.7691 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline | 0.0000 | 4.7856 | 0.0000 |
| | BPA Winter Gasoline | 0.0000 | 4.0568 | 0.0000 |

[32] The Corpus Christi featured only one trip length bin (5 hours). As such, emission factors were not modified for the region under this scenario.

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| | Corpus Summer Gasoline | 0.0000 | 0.0000 | 6.8404 |
| | Corpus Winter Gasoline | 0.0000 | 0.0000 | 4.2200 |
| Kerosene | kerosene (fuel oil #1) | 0.0265 | 0.0000 | 0.0015 |
| | jet kerosene (Jet A) | 0.0059 | 0.0000 | 0.0003 |
| | jet naphtha (JP-4) | 0.1111 | 0.0066 | 0.0057 |
| Naphtha and Solvents | naphtha | 7.4819 | 0.0000 | 0.5342 |
| | solvents (JP-4) | 14.9021 | 1.7459 | 1.0352 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | styrene | 1.1894 | 0.0012 | 0.1502 |
| | cumene | 0.8980 | 0.0008 | 0.1130 |
| | MEK | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 |
| | butyl acrylate | 1.1043 | 0.0003 | 0.1385 |
| | vinyl acetate | 0.0000 | 0.0000 | 0.0000 |
| | xylene | 1.4144 | 0.0090 | 0.1769 |
| | propyl acetate | 1.5258 | 0.0575 | 0.1857 |
| | MIBK | 1.2399 | 0.0070 | 0.1581 |
| Petroleum Products NEC | lube oil | 0.0122 | 0.0000 | 0.0007 |
| Residual Fuel Oil | No. 6 fuel oil | 0.0260 | 0.0000 | 0.0025 |
| | ***Total*** | ***95.6654*** | ***11.4199*** | ***15.2807*** |

Solar absorptance factors appear in the TANKS emission factor equations in three locations, resulting in a non-linear relationship between barge breathing loss estimates and barge color. To investigate the sensitivity of emissions to barge color, solar absorptance was set to 0.97 (representing black paint), and 0.21 (corresponding to a weighted average of good and poor quality white paint). Table 6-10 presents the emission estimates assuming 100 percent black barges, with the remainder of the base case scenario assumptions held constant. The change resulted in VOC emissions increasing by factors between 1.6 (Corpus Christi) and 2.7 (BPA). Interestingly, applying the lower solar absorptance factor for white paint resulted in no emissions from barges, indicative of the importance of solar heating on barge transit emissions.

**Table 6-10. Annual VOC Barge Transit Emissions by Product Type and Region, Black Barges, 2008 (Tons/Year)**

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| Acyclic Hydrocarbons | heptanes | 0.6517 | 0.1520 | 0.1424 |
| | n-decane | 0.1499 | 0.0267 | 0.0383 |
| | 1-heptene | 0.6906 | 0.1599 | 0.1486 |

| WCUS Product Group | Specific Products | HGB | BPA | Corpus Christi |
|---|---|---|---|---|
| | hexane | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.3219 | 0.0591 | 0.0841 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.6406 | 0.0833 | 0.0471 |
| | isopropanol | 0.6103 | 0.0766 | 0.0464 |
| | butanols (iso butyl alcohol) | 0.6674 | 0.0694 | 0.0576 |
| | decanol | 0.0008 | 0.0001 | 0.0001 |
| | hexanol | 0.1918 | 0.0179 | 0.0180 |
| | 2-ethylhexanol | 0.0391 | 0.0034 | 0.0037 |
| Benzene/Toluene | benzene | 2.8737 | 0.5046 | 0.4025 |
| | toluene | 2.6686 | 0.3834 | 0.4340 |
| Carboxylic Acids | acetic acid | 0.4378 | 0.0417 | 0.0349 |
| | propionic acid | 0.1506 | 0.0131 | 0.0129 |
| | butyric acid | 0.0525 | 0.0042 | 0.0046 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 2.7439 | 0.6009 | 1.0800 |
| | #2 diesel | 0.4481 | 0.0955 | 0.1788 |
| | marine diesel oil | 0.4481 | 0.0955 | 0.1788 |
| Gasoline | HGB Summer Gasoline | 15.4915 | 0.0000 | 0.0000 |
| | HGB Winter Gasoline | 10.2561 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline | 0.0000 | 6.0005 | 0.0000 |
| | BPA Winter Gasoline | 0.0000 | 5.0014 | 0.0000 |
| | Corpus Summer Gasoline | 0.0000 | 0.0000 | 10.2339 |
| | Corpus Winter Gasoline | 0.0000 | 0.0000 | 7.2399 |
| Kerosene | kerosene (fuel oil #1) | 0.0136 | 0.0017 | 0.0026 |
| | jet kerosene (Jet A) | 0.0030 | 0.0004 | 0.0006 |
| | jet naphtha (JP-4) | 0.0586 | 0.0114 | 0.0090 |
| Naphtha and Solvents | naphtha | 3.5673 | 0.9352 | 0.9253 |
| | solvents (JP-4) | 7.8584 | 3.0285 | 1.6219 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | styrene | 0.6151 | 0.1022 | 0.2612 |
| | cumene | 0.4582 | 0.0761 | 0.1975 |
| | MEK | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 |
| | butyl acrylate | 0.5642 | 0.0945 | 0.2447 |
| | vinyl acetate | 0.0000 | 0.0000 | 0.0000 |
| | xylene | 0.7295 | 0.1259 | 0.3040 |
| | propyl acetate | 0.8102 | 0.1660 | 0.3042 |
| | MIBK | 0.6560 | 0.1087 | 0.2746 |
| Petroleum Products NEC | lube oil | 0.0063 | 0.0012 | 0.0012 |
| Residual Fuel Oil | No. 6 fuel oil | 0.0134 | 0.0018 | 0.0046 |
| | ***Total*** | ***54.8885*** | ***18.0428*** | ***24.5380*** |

## 6.5 Validation and Quality Assurance

*Validation*

The VTS barge dimension data, along with information regarding loaded barge trip numbers, provides an opportunity for an independent validation of the WCUS product volume estimates. Barge tank dimensions were included with the HGB area VTS data, containing barge dimensions (in feet) for length, width, and height. The corresponding barge tank volumes were then estimated in cubic feet from these dimensions, and based on industry input it was agreed that the average liquid volume of a loaded barge corresponds to 97 percent of the total barge volume. Calculated barge volumes were then converted to barrels of oil (US) based on 5.61 cubic feet per barrel. The distribution of barge sizes obtained for the HGB region (as shown in Figure 6-1) was then applied to the BPA and Corpus Christi study areas, since barge dimension information was not provided for these regions. Barge volumes were then combined with the number of loaded trips to estimate total product transport volumes by region. The calculated volumes are compared to the corresponding WCUS volumes in Table 6-11.

**Table 6-11. Annual Product Volume Estimates by Region and Data Source ('000s bbls)**

| | ***Region*** | |
|---|---|---|
| **Method** | **HGB** | **BPA** |
| WCUS | 869 | 596 |
| VTS | 1,313 | 629 |

While the two methods for estimating product volumes appear to reasonably close for the BPA area, the results for the HGB region are substantially different, with the VTS trip-based methodology resulting in significantly higher estimates. This discrepancy may be explained by two factors. First, foreign product shipments, which would not be found in the WCUS estimates but would be recorded in the regional VTS data, are likely much more common in the HGB region than in the BPA region. Second, fleeting operations are not recorded in the WCUS, while the VTS recorded a large fraction of short trips (less than 2 hours, suspected to represent fleeting activity) for the HGB.[33]

[33] While WCUS product volumes are similar for the HGB and BPA regions, VTS annual towboat trip data appear to indicate much higher activity in the HGB, as expected (29,958/yr for BPA; 81,968/yr for HGB).

*Quality Assurance*

Extensive quality assurance checks were performed to ensure the accuracy of the data and calculations used in this study. Evaluation of activity data involved several checks. Given the complex routing for the HGB region, significant resources were dedicated to analyze the barge configurations, trip logic, route segmentation, speeds, transit times, and the associated computer code. There were over 100,000 rows of raw data in the HGB VTS data set representing individual towboat/tugboat trips. The total trip counts appear to be consistent with previous work done for the Port of Houston Authority which estimated emissions from towboats and tugboats. Historically, VTS towboat data files have recorded slightly over 100,000 movements per year (2007 and 2008 VTS).

After screening the VTS records for tank barges, 83,180 towboat/barge "unit tows" remained. Using origination-destination pairs, these trip routes were located with GPS coordinates, assigned to channel routes, and parsed into as many as 60 channel segments, varying between a fraction of a nautical mile to nearly 10 miles. This process allocated the 83,180 trips to 928,408 data elements.

One of the routes near the San Jacinto River, a major fleeting and towboat terminal area, was found to be mis-assigned due to a faulty spelling during a database merge. Correction resulted in improved routing and made the number of trips total correctly.

Another issue surfaced when the ICW was extended east and west of the VTS service area to the study area boundaries. The actual VTS service area stops at Pelican Island near Galveston and Bolivar on the other side of the Houston Ship Channel from Galveston. When analyzed, 92 of 83,180 trips (0.11%) had exceptionally long trip times (greater than 24 hours), mainly on the eastern portion of ICW involving trips from Bolivar to Port Arthur. These anomalously long trips seemed to result from random time stamp errors. Time stamps for these trips were checked for doubling counting, but none were identified. Even with these seemingly long trips, which may have involved trips to Freeport of the Upper Houston Ship Channel, the transit speeds appeared reasonable – about 5.5 knots including maneuvering. These trips were allocated to the 16 hour trip length bin for calculation of HGB emission estimates.

Each calculation element of the TANKS emission factor equations were also checked independently within the project working files (provided to the TCEQ in electronic format) to confirm the accuracy of spreadsheet formulas. Additional internal consistency checks were also performed, including comparison of seasonal emission rates, emission levels across regions, and emission factors across the range of product vapor pressures, as described below.

Figures 6-5, 6-6, and 6-7 illustrate monthly VOC emissions totals, for base case controlled conditions, across an entire year. As expected, emission totals are generally higher in the warmer months, with discontinuities seen in the March and September time periods, due to changes between winter and summer gasolines.

**Figure 6-5. Monthly VOC Emission Totals, HGB Region (lbs/month)**

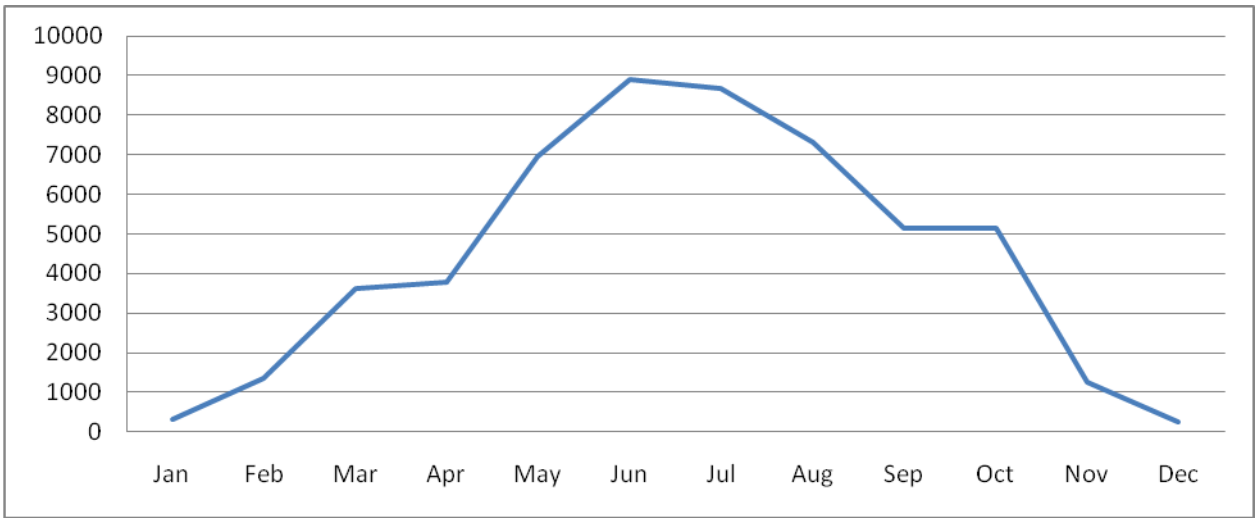



**Figure 6-6. Monthly VOC Emission Totals, BPA Region (lbs/month)**

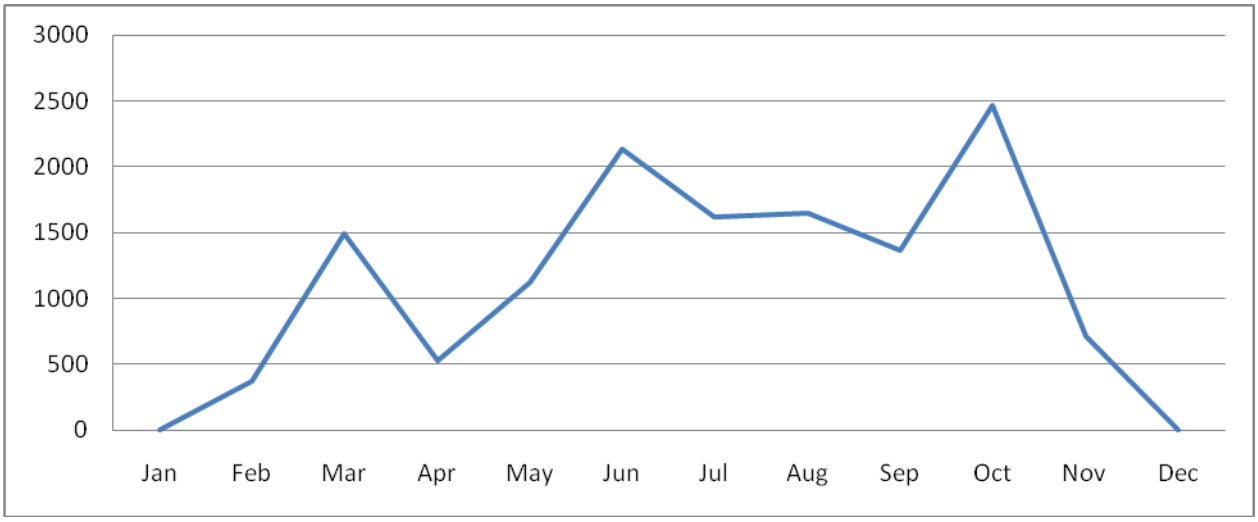
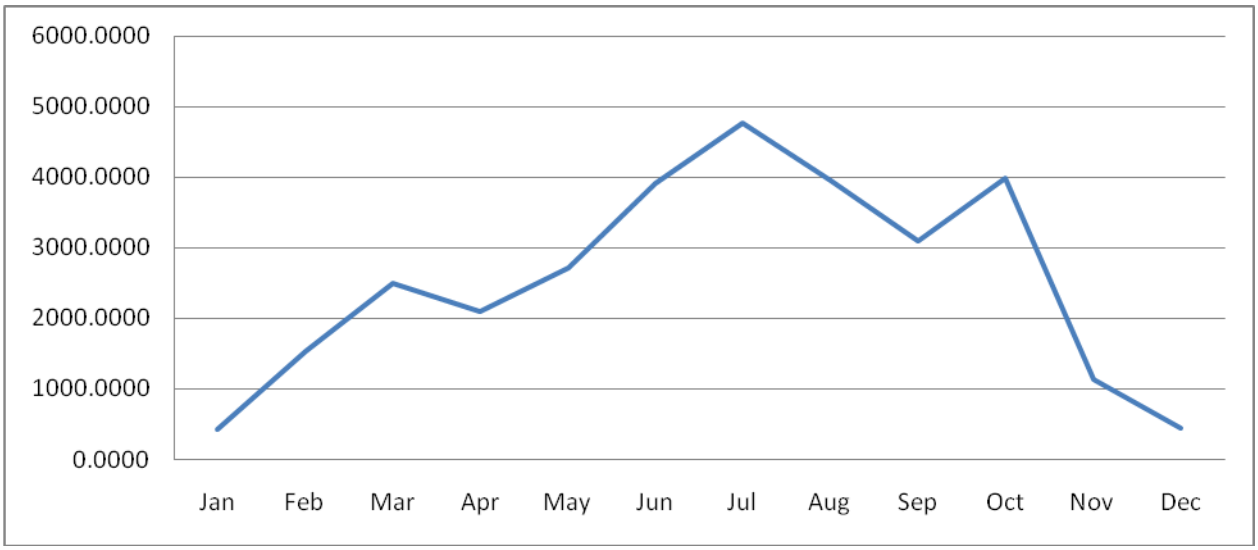


**Figure 6-7. Monthly VOC Emission Totals, Corpus Christi Region (lbs/month)**



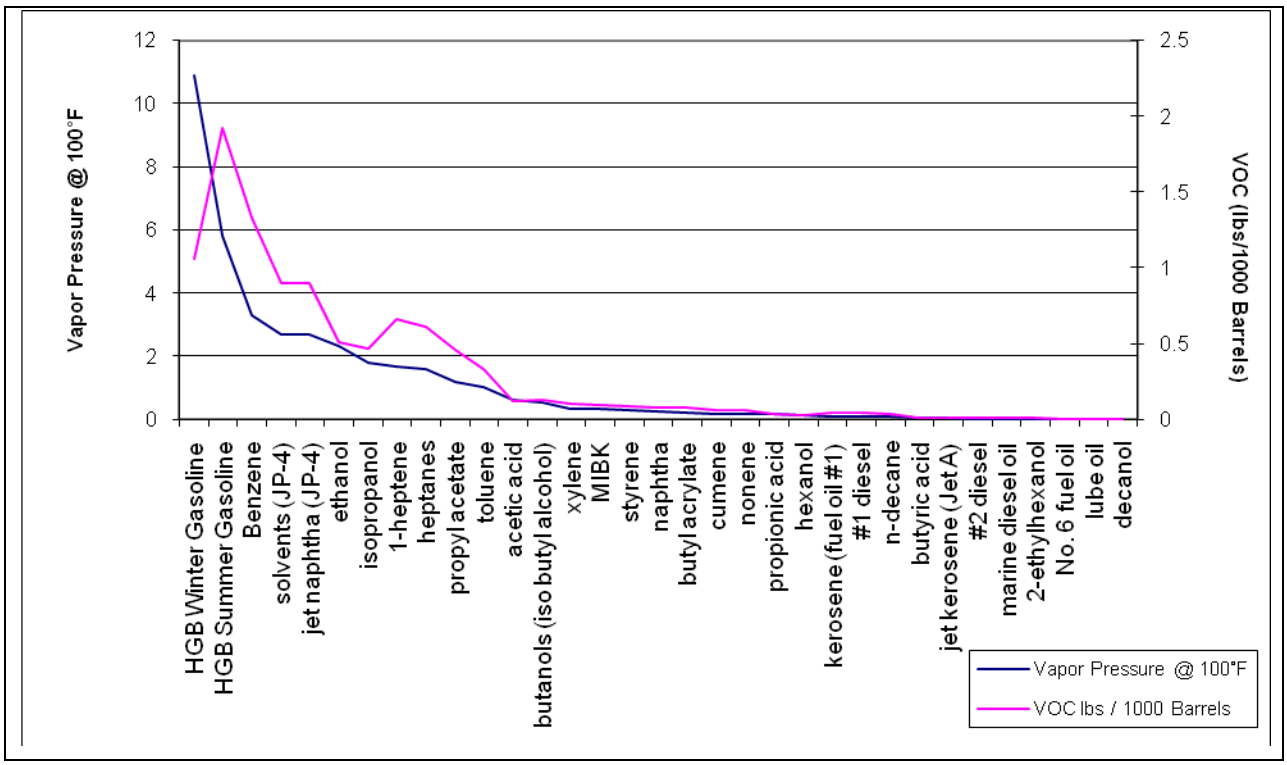

Emission factors and total emissions for the HGB region were also cross-checked with product vapor pressure estimates, as shown in Table 6-12. The data in this table are sorted by product vapor pressure, excluding those products with no base case emissions. In general emission factors should correlate closely with associated product vapor pressures. In fact, the corresponding VOC emission factors shown in the table are largely sorted from highest to lowest as well, as expected.

## Table 6-12. Base Case VOC Emissions Ranked by Vapor Pressure, HGB Region

| WCUS Product Group | Specific Products | Vapor Pressure @ 100˚F | VOC lbs / 1,000 Barrels | VOC (Tons/Yr) | Volume (Barrels/Yr) |
|---|---|---|---|---|---|
| Gasoline | HGB Winter Gasoline | 10.9 | 1.05809 | 4.9254 | 9,309,993 |
| Gasoline | HGB Summer Gasoline | 5.8 | 1.91725 | 8.9248 | 9,309,993 |
| Benzene/Toluene | Benzene | 3.3 | 1.33058 | 1.5409 | 2,316,131 |
| Naphtha and Solvents | solvents (JP-4) | 2.7 | 0.89754 | 3.9004 | 8,691,266 |
| Kerosene | jet naphtha (JP-4) | 2.7 | 0.89830 | 0.0291 | 64,789 |
| Alcohols | ethanol | 2.32 | 0.50967 | 0.3261 | 1,279,661 |
| Alcohols | isopropanol | 1.779 | 0.46450 | 0.2972 | 1,279,661 |
| Acyclic Hydrocarbons | 1-heptene | 1.692 | 0.65849 | 0.3212 | 975,565 |
| Acyclic Hydrocarbons | heptanes | 1.586 | 0.60826 | 0.2967 | 975,565 |
| Other Hydrocarbons | propyl acetate | 1.193 | 0.45793 | 0.3609 | 1,576,228 |
| Benzene/Toluene | toluene | 1.006 | 0.33167 | 1.1523 | 6,948,393 |
| Carboxylic Acids | acetic acid | 0.616 | 0.11688 | 0.1749 | 2,992,845 |
| Alcohols | butanols (iso butyl alcohol) | 0.541 | 0.12505 | 0.2667 | 4,265,538 |
| Other Hydrocarbons | xylene | 0.336 | 0.10529 | 0.2766 | 5,254,094 |
| Other Hydrocarbons | MIBK | 0.333 | 0.09414 | 0.2473 | 5,254,094 |
| Other Hydrocarbons | styrene | 0.295 | 0.08492 | 0.2231 | 5,254,094 |
| Naphtha and Solvents | naphtha | 0.266 | 0.08143 | 1.1796 | 28,970,888 |
| Other Hydrocarbons | butyl acrylate | 0.226 | 0.07716 | 0.2027 | 5,254,094 |
| Other Hydrocarbons | cumene | 0.19 | 0.06273 | 0.1648 | 5,254,094 |
| Acyclic Hydrocarbons | nonene | 0.179 | 0.06458 | 0.105 | 3,251,882 |
| Carboxylic Acids | propionic acid | 0.179 | 0.03609 | 0.054 | 2,992,845 |
| Alcohols | hexanol | 0.123 | 0.03052 | 0.0651 | 4,265,538 |
| Kerosene | kerosene (fuel oil #1) | 0.1 | 0.04353 | 0.0047 | 215,963 |
| Distillate Fuel Oils | #1 diesel | 0.097 | 0.04434 | 0.9372 | 42,268,957 |
| Acyclic Hydrocarbons | n-decane | 0.083 | 0.03192 | 0.0519 | 3,251,882 |
| Carboxylic Acids | butyric acid | 0.058 | 0.01223 | 0.0183 | 2,992,845 |
| Kerosene | jet kerosene (Jet A) | 0.029 | 0.00926 | 0.001 | 215,963 |
| Distillate Fuel Oils | #2 diesel | 0.022 | 0.00706 | 0.1493 | 42,268,957 |
| Distillate Fuel Oils | marine diesel oil | 0.022 | 0.00706 | 0.1493 | 42,268,957 |
| Alcohols | 2-ethylhexanol | 0.019 | 0.00614 | 0.0131 | 4,265,538 |
| Residual Fuel Oil | No. 6 fuel oil | 0.019 | 0.00008 | 0.0044 | 106,606,551 |
| Petroleum Products NEC | lube oil | 0.001 | 0.00028 | 0.0021 | 14,981,666 |
| Alcohols | decanol | 0 | 0.00014 | 0.0003 | 4,265,538 |

Some discrepancies were identified between the sorted vapor pressure and associated emission factor values however, as shown in Figure 6-7. Most evident is the relative ranking of winter and summer gasoline, which results from the different temperature ranges which influence the resulting emission factors for these products. In another example, a deviation in the downward emission factor trend can be seen moving between isopropanol and 1-heptene. Upon investigation it was determined that these differences in molecular weight ($M_v$ in Equation 5), which impact vapor densities, are the cause of these apparent discrepancies.

**Figure 6-8. Vapor Pressure vs. Emission Factors, HGB Region**




Finally, QA activities associated with toxic emission development focused primarily on the selection of the most appropriate speciation profiles from U.S. EPA's SPECIATE database. The speciation profiles used for crude oil and gasoline were actually composite profiles contained within SPECIATE. Although there were no profiles specifically identified as representing evaporative emissions from barges, the selected profiles appeared to be reasonable surrogates. The SPECIATE database contains a significant number of liquid composition profiles, and care was taken to ensure that evaporative (i.e., vapor or headspace) profiles were used. The distillate, naphtha, and solvent profiles were developed as averages from a number of applicable profiles. The distillate profile was based on six SPECIATE diesel headspace vapor

profiles, while the naphtha profile was based on eight SPECIATE naphtha profiles. For the solvent profile, there were not any specific solvent profiles in SPECIATE. As a result, 10 profiles for mineral spirits and Stoddard solvents were averaged together.

After profiles were taken directly from SPECIATE or developed from a group of SPECIATE profiles, the profile species were examined. Although not all species are commonly known, the profiles were examined to determine the presence of several species that would be expected from evaporative source categories, including benzene, ethylbenzene, toluene, xylenes (m-,o-, and p- isomers), n-hexane, etc. These species typically ranged from 0.5 percent to several percent, which is reasonable. In addition, most of the profiles also had a fraction of species that were unknown or unidentified. This is also typical of speciation profiles.

# 7.0 Conclusions and Recommendations

This project provided estimates of VOC emissions from barge transit activities for the study areas, assuming properly operating pressure valves, hatches, and other containment points. The 2008 base case annual VOC emission estimates for each area were relatively low, totaling 26.4, 6.7, and 15.3 tons per year for the HGB, BPA, and Corpus Christi regions, respectively. Key contributors to these totals include gasoline, benzene, naptha and solvents, toluene, and #1 diesel. Although the HGB area product volumes were substantially higher than the other two areas, the area's associated VOC emissions were relatively low due to the preponderance of short trips; trips of only a few hours in length undergo substantially less heating and vapor space pressure expansion than longer trips. Similarly, empty barges are estimated to be responsible for the majority of total VOC emissions due to their large vapor spaces, even though saturation levels are significantly lower than in loaded barges.

The associated 2008 HAP emission estimates are correspondingly low, totaling 0.37, 0.23, and 0.67 tons per year for the HGB, BPA, and Corpus Christ regions, respectively. Annual HRVOC estimates total 0.02, 0.01, and 0.05 tons per year for these same regions.

Uncontrolled emission estimates corresponding to the exclusive use of 1 psi barges were substantially higher than the controlled base case, totaling 163, 47, and 75 tons per year for the HGB, BPA, and Corpus Christi regions, respectively. Therefore properly operating barge control systems are estimated to provide an 83 percent control effectiveness. This effectiveness should increase even further in the future with the retirement of 1 psi barges that are replaced by 3 psi and 6 psi barges.

The study's sensitivity analysis highlighted the importance of properly matching product vapor pressures with the appropriate barge psi rating; for example, placing all HGB region product in 1 psi barges would increase emissions by a factor of 6. Similarly, variations in trip length distribution, barge color, and product vapor pressure all have substantial impacts on VOC emission rates.

Finally, additional uncertainty arises from the use of the TANKS equations to model emissions from 1 psi barges.

A number of steps could be made to reduce these uncertainties and improve the accuracy and precision of these results, including:

- *Conduct remote sensing to estimate gross emitter frequency*. A systematic application of optical remote sensing could be used to estimate the fraction of the operating barge fleet with significant leaks, although defining a discrete threshold for "significant" would be necessarily subjective. Site selection and sample number targets would require a detailed statistical evaluation. Ideally, information regarding barge pressure ratings and products would be collected as well.
- *Conduct on-board flux measurements*. Similar to the EPA optical remote sensing study, OTM, bagging, or flow meter studies could be performed to quantify emission rates for barges identified as high emitters, for specific products. Measurements could be expanded to include other potential emission points such as release stacks. Expanding source measurements to a random sample of barges (to include "regular emitters") would provide an independent means of extrapolating emission estimates to the entire barge fleet.
- *Refine the TANKS calculation methodology*. As noted above, the TANKS model equations may require adjustments to accurately estimate barge transit emissions for controlled conditions. These adjustments may be established through further engineering analysis and direct measurement.
- *Improve activity profile inputs*. A detailed survey of barge operators could provide more accurate information regarding actual product types, volumes, barge psi/product type assignments, trip lengths, and travel routes. The trip length and route information would be particularly useful in characterizing fleeting operations as well as multi-day trips that are not quantifiable under the current methodology.

## 8.0 References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# Appendix A
# Calculated Product Vapor Pressures

| | | | | | | Vapor Pressure (psia) at __ degrees F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Specific Products** | **Specific Gravity** | **Specific Gravity Temp** | **Liquid Density @ degrees & Units** | **CONVERTED Liquid Density @ Approx. 60°F (lb/gal)** | **Liquid Density at 60 degrees F (lb/gal)** | **40** | **50** | **60** | **70** | **80** | **90** | **100** |
| heptanes | | | | | 5.727 | 0.29 | 0.406 | 0.541 | 0.735 | 0.967 | 1.238 | 1.586 |
| n-decane | 0.73 | 60°F | | 6.089 | | | 0.001 | 0.017 | 0.034 | 0.050 | 0.067 | 0.083 |
| 1-heptene | 0.697 | 68°F | | 5.814 | | | 0.078 | 0.453 | 0.828 | 1.203 | 1.578 | 1.953 |
| hexane | | | | | 5.527 | 1.102 | 1.45 | 1.876 | 2.436 | 3.055 | 3.906 | 4.892 |
| nonene | 0.739 | 68°F | | 6.164 | | 0.121 | 0.131 | 0.140 | 0.150 | 0.160 | 0.169 | 0.179 |
| methanol | | | | | 6.63 | 0.735 | 1.006 | 1.412 | 1.953 | 2.61 | 3.461 | 4.525 |
| ethanol | | | | | 6.61 | 0.193 | 0.406 | 0.619 | 0.87 | 1.218 | 1.682 | 2.32 |
| isopropanol | | | | | 6.573 | 0.213 | 0.329 | 0.483 | 0.677 | 0.928 | 1.296 | 1.779 |
| butanols (iso Butyl Alcohol) | | | | | 6.712 | 0.058 | 0.097 | 0.135 | 0.193 | 0.271 | 0.387 | 0.541 |
| decanol | | | 1.0695 g/cm3 @ 68°F | 8.925 | | | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0003 |
| hexanol | 0.85 | 68°F | | 7.090 | | | 0.0049 | 0.0068 | 0.0097 | 0.0136 | 0.0194 | 0.0271 |
| 2-ethylhexanol | 0.834 | 68°F | | 6.957 | | | 0.003492 | 0.00486 | 0.00696 | 0.009756 | 0.013932 | 0.019476 |
| Benzene | | | | | 7.365 | 0.638 | 0.87 | 1.16 | 1.508 | 1.972 | 2.61 | 3.287 |
| Toluene | | | | | 7.261 | 0.174 | 0.213 | 0.309 | 0.425 | 0.58 | 0.773 | 1.006 |
| acetic acid | | | | | 8.757 | 0.074 | 0.020 | 0.116 | 0.213 | 0.310 | 0.406 | 0.503 |
| propionic acid | 0.995 | 68°F | | 8.300 | | 0.019 | 0.040 | 0.048 | 0.056 | 0.064 | 0.072 | 0.080 |
| butyric acid | 0.96 | | | 8.008 | | | 0.011 | 0.014 | 0.016 | 0.018 | 0.021 | 0.023 |
| Assume non-volatile | | | | | | | | | | | | |
| Assume non-volatile | | | | | | | | | | | | |
| crude oil | | | | | 7.3436 | 0.63 | 0.81 | 0.98 | 1.19 | 1.40 | 1.68 | 2.00 |
| crude oil RVP 5 | | | | | 7.1 | 1.8 | 2.3 | 2.8 | 3.4 | 4 | 4.8 | 5.7 |
| #1 diesel | 0.8075 | | | 6.736 | | 0.013621 | 0.019773 | 0.028561 | 0.039546 | 0.052728 | 0.070304 | 0.096668 |
| #2 diesel | | | | | 7.1 | 0.0031 | 0.0045 | 0.0065 | 0.009 | 0.012 | 0.016 | 0.022 |
| marine diesel oil | | | | | 7.1724 | 0.0031 | 0.0045 | 0.0065 | 0.009 | 0.012 | 0.016 | 0.022 |
| gas oil | | | 890 kg/m3 @ 60°F | 7.427 | | | | | | | | |
| Gasoline RVP 6 | | | | | 5.6 | 2.05 | 2.6 | 3.15 | 3.85 | 4.6 | 5.5 | 6.55 |
| Gasoline RVP 7 | | | | | 5.6 | 2.3 | 2.9 | 3.5 | 4.3 | 5.2 | 6.2 | 7.4 |
| Gasoline RVP 7.8 | | | | | 5.6 | 2.5929 | 3.2079 | 3.9363 | 4.793 | 5.7937 | 6.9552 | 8.2952 |
| Gasoline RVP 8.3 | | | | | 5.6 | 2.7888 | 3.444 | 4.2188 | 5.1284 | 6.1891 | 7.4184 | 8.8344 |
| Gasoline RVP 10 | | | | | 5.6 | 3.4 | 4.2 | 5.2 | 6.2 | 7.4 | 8.8 | 10.5 |
| Gasoline RVP 11.5 | | | | | 5.6 | 4.087 | 4.9997 | 6.069 | 7.3132 | 8.7519 | 10.4053 | 12.2949 |
| Gasoline RVP 13 | | | | | 5.6 | 4.7 | 5.7 | 6.9 | 8.3 | 9.9 | 11.7 | 13.8 |

| | | | | | | Vapor Pressure (psia) at __ degrees F | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Specific Products** | **Specific Gravity** | **Specific Gravity Temp** | **Liquid Density @ degrees & Units** | **CONVERTED Liquid Density @ Approx. 60°F (lb/gal)** | **Liquid Density at 60 degrees F (lb/gal)** | **40** | **50** | **60** | **70** | **80** | **90** | **100** |
| kerosene (Fuel Oil #1) | | | | | 7.01 | 0.014104 | 0.02064 | 0.02924 | 0.03784 | 0.0516 | 0.07224 | 0.1 |
| jet kerosene (Jet A) | | | | | 7 | 0.0041 | 0.006 | 0.0085 | 0.011 | 0.015 | 0.021 | 0.029 |
| jet naphtha (JP-4) | | | | | 6.4 | 0.8 | 1 | 1.3 | 1.6 | 1.9 | 2.4 | 2.7 |
| Naphtha | | | | | 6.25875 | 0.140 | 0.161 | 0.182 | 0.203 | 0.224 | 0.245 | 0.266 |
| Coker gas | | | | | Use data for JP-4 as surrogate for solvents, alkylates, etc. | | | | | | | |
| Cat Gas | | | | | | 0.8 | 1 | 1.3 | 1.6 | 1.9 | 2.4 | 2.7 |
| Alkylates | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Assume non-volatile | | | | | | | | | | | | |
| Assume non-volatile | | | | | | | | | | | | |
| Styrene | | | | | 7.55604 | 0.144 | 0.205 | 0.265 | 0.326 | 0.386 | 0.447 | 0.508 |
| Cumene | | | | | 7.18908 | 0.027 | 0.054 | 0.081 | 0.109 | 0.136 | 0.163 | 0.190 |
| MEK | | | | | 6.747 | 0.715 | 0.928 | 1.199 | 1.489 | 2.069 | 2.668 | 3.345 |
| MTBE | | | | | 6.1716 | 2.47 | 3.18 | 4.09 | 4.74 | 6.32 | 7.79 | 9.26 |
| Butyl Acrylate | | | | | 7.420932 | 0.017 | 0.035 | 0.052 | 0.070 | 0.088 | 0.105 | 0.123 |
| Vinyl Acetate | | | | | 7.817 | 0.735 | 0.986 | 1.296 | 1.721 | 2.262 | 3.113 | 4.022 |
| Xylene | | | | | 7.1724 | 0.016 | 0.082 | 0.148 | 0.174 | 0.186 | 0.254 | 0.342 |
| Propyl Acetate | | | | | 6.97224 | 0.043 | 0.227 | 0.411 | 0.483 | 0.732 | 0.866 | 1.000 |
| MIBK | | | | | 6.68868 | 0.070 | 0.119 | 0.167 | 0.215 | 0.264 | 0.312 | 0.360 |
| Lube oil | | | | | 7.506 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0006 |
| Light and Heavy Cycle Oils | | | | | Assume equivalent to lube oil | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0006 |
| Residual Fuel | | | | | 8.219825 | 0.002 | 0.003 | 0.004 | 0.006 | 0.009 | 0.013 | 0.019 |
| Marine Residual Fuel | | | 1010 kg/m3 @ 59°F | 8.429 | | 0.01332 | 0.01998 | 0.02664 | 0.04 | 0.05994 | 0.08658 | 0.12654 |
| No. 6 Fuel Oil | | | | | 7.9 | 0.00002 | 0.00003 | 0.00004 | 0.00006 | 0.00009 | 0.00013 | 0.00019 |
| Coker Feed | 1 | | | 8.342 | | | | | | | | |
| Asphalt | | | | | 8.4234 | | | | | negligible | | |

| | Vapor Pressure at Specific Temperatures | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature:** | **40** | **41** | **42** | **43** | **44** | **45** | **46** | **47** | **48** | **49** | **50** | **51** | **52** | **53** | **54** | **55** |
| heptanes | 0.29 | 0.3016 | 0.3132 | 0.3248 | 0.3364 | 0.348 | 0.3596 | 0.3712 | 0.3828 | 0.3944 | 0.406 | 0.4195 | 0.433 | 0.4465 | 0.46 | 0.4735 |
| n-decane | 0.00102 | 0.0019 | 0.0027 | 0.0035 | 0.0043 | 0.0052 | 0.006 | 0.0068 | 0.0077 | 0.0085 | 0.0093 | 0.0102 | 0.011 | 0.0118 | 0.0127 | 0.0135 |
| 1-heptene | 0.38036 | 0.3813 | 0.3822 | 0.3831 | 0.384 | 0.3849 | 0.3858 | 0.3867 | 0.403 | 0.4193 | 0.4355 | 0.4518 | 0.4681 | 0.4844 | 0.5006 | 0.5169 |
| hexane | 1.102 | 1.1368 | 1.1716 | 1.2064 | 1.2412 | 1.276 | 1.3108 | 1.3456 | 1.3804 | 1.4152 | 1.45 | 1.4926 | 1.5352 | 1.5778 | 1.6204 | 1.663 |
| nonene | 0.121 | 0.122 | 0.1229 | 0.1239 | 0.1249 | 0.1258 | 0.1268 | 0.1278 | 0.1287 | 0.1297 | 0.1307 | 0.1316 | 0.1326 | 0.1336 | 0.1345 | 0.1355 |
| methanol | 0.735 | 0.7621 | 0.7892 | 0.8163 | 0.8434 | 0.8705 | 0.8976 | 0.9247 | 0.9518 | 0.9789 | 1.006 | 1.0466 | 1.0872 | 1.1278 | 1.1684 | 1.209 |
| ethanol | 0.193 | 0.2143 | 0.2356 | 0.2569 | 0.2782 | 0.2995 | 0.3208 | 0.3421 | 0.3634 | 0.3847 | 0.406 | 0.4273 | 0.4486 | 0.4699 | 0.4912 | 0.5125 |
| isopropanol | 0.213 | 0.2246 | 0.2362 | 0.2478 | 0.2594 | 0.271 | 0.2826 | 0.2942 | 0.3058 | 0.3174 | 0.329 | 0.3444 | 0.3598 | 0.3752 | 0.3906 | 0.406 |
| butanols (iso Butyl Alcohol) | 0.058 | 0.0619 | 0.0658 | 0.0697 | 0.0736 | 0.0775 | 0.0814 | 0.0853 | 0.0892 | 0.0931 | 0.097 | 0.1008 | 0.1046 | 0.1084 | 0.1122 | 0.116 |
| decanol | 0 | 6E-06 | 1E-05 | 2E-05 | 2E-05 | 3E-05 | 3E-05 | 4E-05 | 5E-05 | 5E-05 | 6E-05 | 6E-05 | 6E-05 | 7E-05 | 7E-05 | 7E-05 |
| hexanol | 0.00019 | 0.0013 | 0.0023 | 0.0034 | 0.0044 | 0.0055 | 0.0066 | 0.0076 | 0.0087 | 0.0098 | 0.0108 | 0.0119 | 0.013 | 0.014 | 0.0151 | 0.0161 |
| 2-ethylhexanol | 0 | 0.0003 | 0.0007 | 0.001 | 0.0014 | 0.0017 | 0.0021 | 0.0024 | 0.0028 | 0.0031 | 0.0035 | 0.0036 | 0.0038 | 0.0039 | 0.004 | 0.0042 |
| Benzene | 0.638 | 0.6612 | 0.6844 | 0.7076 | 0.7308 | 0.754 | 0.7772 | 0.8004 | 0.8236 | 0.8468 | 0.87 | 0.899 | 0.928 | 0.957 | 0.986 | 1.015 |
| Toluene | 0.174 | 0.1779 | 0.1818 | 0.1857 | 0.1896 | 0.1935 | 0.1974 | 0.2013 | 0.2052 | 0.2091 | 0.213 | 0.2226 | 0.2322 | 0.2418 | 0.2514 | 0.261 |
| acetic acid | 0.0823 | 0.0871 | 0.0919 | 0.0967 | 0.1015 | 0.1063 | 0.1111 | 0.1159 | 0.1207 | 0.1255 | 0.1303 | 0.135 | 0.1398 | 0.1446 | 0.1494 | 0.1542 |
| propionic acid | 0.01934 | 0.0212 | 0.023 | 0.0248 | 0.0267 | 0.0285 | 0.0304 | 0.0322 | 0.034 | 0.0359 | 0.0377 | 0.0395 | 0.0414 | 0.0432 | 0.045 | 0.0469 |
| butyric acid | 3.6E-05 | 0.0001 | 0.0003 | 0.0004 | 0.0005 | 0.0006 | 0.0008 | 0.0009 | 0.0011 | 0.0012 | 0.0014 | 0.0015 | 0.0017 | 0.0018 | 0.002 | 0.0021 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crude oil | 0.63158 | 0.6491 | 0.6667 | 0.6842 | 0.7018 | 0.7193 | 0.7368 | 0.7544 | 0.7719 | 0.7895 | 0.807 | 0.8246 | 0.8421 | 0.8596 | 0.8772 | 0.8947 |
| crude oil RVP 5 | 1.8 | 1.85 | 1.9 | 1.95 | 2 | 2.05 | 2.1 | 2.15 | 2.2 | 2.25 | 2.3 | 2.35 | 2.4 | 2.45 | 2.5 | 2.55 |
| #1 diesel | 0.01362 | 0.0142 | 0.0149 | 0.0155 | 0.0161 | 0.0167 | 0.0173 | 0.0179 | 0.0185 | 0.0192 | 0.0198 | 0.0207 | 0.0215 | 0.0224 | 0.0233 | 0.0242 |
| #2 diesel | 0.0031 | 0.0032 | 0.0034 | 0.0035 | 0.0037 | 0.0038 | 0.0039 | 0.0041 | 0.0042 | 0.0044 | 0.0045 | 0.0047 | 0.0049 | 0.0051 | 0.0053 | 0.0055 |
| marine diesel oil | 0.0031 | 0.0032 | 0.0034 | 0.0035 | 0.0037 | 0.0038 | 0.0039 | 0.0041 | 0.0042 | 0.0044 | 0.0045 | 0.0047 | 0.0049 | 0.0051 | 0.0053 | 0.0055 |
| gas oil | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gasoline RVP 6 | 2.05 | 2.105 | 2.16 | 2.215 | 2.27 | 2.325 | 2.38 | 2.435 | 2.49 | 2.545 | 2.6 | 2.655 | 2.71 | 2.765 | 2.82 | 2.875 |
| Gasoline RVP 7 | 2.3 | 2.36 | 2.42 | 2.48 | 2.54 | 2.6 | 2.66 | 2.72 | 2.78 | 2.84 | 2.9 | 2.96 | 3.02 | 3.08 | 3.14 | 3.2 |
| Gasoline RVP 7.8 | 2.5929 | 2.6544 | 2.7159 | 2.7774 | 2.8389 | 2.9004 | 2.9619 | 3.0234 | 3.0849 | 3.1464 | 3.2079 | 3.2807 | 3.3536 | 3.4264 | 3.4993 | 3.5721 |
| Gasoline RVP 8.3 | 2.7888 | 2.8543 | 2.9198 | 2.9854 | 3.0509 | 3.1164 | 3.1819 | 3.2474 | 3.313 | 3.3785 | 3.444 | 3.5215 | 3.599 | 3.6764 | 3.7539 | 3.8314 |
| Gasoline RVP 10 | 3.4 | 3.48 | 3.56 | 3.64 | 3.72 | 3.8 | 3.88 | 3.96 | 4.04 | 4.12 | 4.2 | 4.3 | 4.4 | 4.5 | 4.6 | 4.7 |

| | Vapor Pressure at Specific Temperatures | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature:** | **40** | **41** | **42** | **43** | **44** | **45** | **46** | **47** | **48** | **49** | **50** | **51** | **52** | **53** | **54** | **55** |
| Gasoline RVP 11.5 | 4.087 | 4.1783 | 4.2695 | 4.3608 | 4.4521 | 4.5434 | 4.6346 | 4.7259 | 4.8172 | 4.9084 | 4.9997 | 5.1066 | 5.2136 | 5.3205 | 5.4274 | 5.5344 |
| Gasoline RVP 13 | 4.7 | 4.8 | 4.9 | 5 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 5.6 | 5.7 | 5.82 | 5.94 | 6.06 | 6.18 | 6.3 |
| kerosene (Fuel Oil #1) | 0.0141 | 0.0148 | 0.0154 | 0.0161 | 0.0167 | 0.0174 | 0.018 | 0.0187 | 0.0193 | 0.02 | 0.0206 | 0.0215 | 0.0224 | 0.0232 | 0.0241 | 0.0249 |
| jet kerosene (Jet A) | 0.0041 | 0.0043 | 0.0045 | 0.0047 | 0.0049 | 0.0051 | 0.0052 | 0.0054 | 0.0056 | 0.0058 | 0.006 | 0.0063 | 0.0065 | 0.0068 | 0.007 | 0.0073 |
| jet naphtha (JP-4) | 0.8 | 0.82 | 0.84 | 0.86 | 0.88 | 0.9 | 0.92 | 0.94 | 0.96 | 0.98 | 1 | 1.03 | 1.06 | 1.09 | 1.12 | 1.15 |
| Naphtha | 0.13962 | 0.1417 | 0.1438 | 0.146 | 0.1481 | 0.1502 | 0.1523 | 0.1544 | 0.1565 | 0.1586 | 0.1607 | 0.1629 | 0.165 | 0.1671 | 0.1692 | 0.1713 |
| Coker gas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cat Gas | 0.8 | 0.82 | 0.84 | 0.86 | 0.88 | 0.9 | 0.92 | 0.94 | 0.96 | 0.98 | 1 | 1.03 | 1.06 | 1.09 | 1.12 | 1.15 |
| Alkylates | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Styrene | 0.05545 | 0.0572 | 0.0589 | 0.0606 | 0.0623 | 0.064 | 0.0658 | 0.0675 | 0.0692 | 0.0709 | 0.0726 | 0.0743 | 0.0761 | 0.0778 | 0.0795 | 0.0812 |
| Cumene | 0.02508 | 0.0269 | 0.0287 | 0.0305 | 0.0322 | 0.034 | 0.0358 | 0.0376 | 0.0394 | 0.0412 | 0.043 | 0.0448 | 0.0466 | 0.0484 | 0.0501 | 0.0519 |
| MEK | 0.715 | 0.7363 | 0.7576 | 0.7789 | 0.8002 | 0.8215 | 0.8428 | 0.8641 | 0.8854 | 0.9067 | 0.928 | 0.9551 | 0.9822 | 1.0093 | 1.0364 | 1.0635 |
| MTBE | 2.46746 | 2.5389 | 2.6104 | 2.6818 | 2.7533 | 2.8247 | 2.8962 | 2.9677 | 3.0391 | 3.1106 | 3.182 | 3.2729 | 3.3638 | 3.4546 | 3.5455 | 3.6364 |
| Butyl Acrylate | 0.03582 | 0.0376 | 0.0394 | 0.0412 | 0.043 | 0.0448 | 0.0466 | 0.0484 | 0.0501 | 0.0519 | 0.0537 | 0.0555 | 0.0573 | 0.0591 | 0.0609 | 0.0627 |
| Vinyl Acetate | 0.735 | 0.7601 | 0.7852 | 0.8103 | 0.8354 | 0.8605 | 0.8856 | 0.9107 | 0.9358 | 0.9609 | 0.986 | 1.017 | 1.048 | 1.079 | 1.11 | 1.141 |
| Xylene | 0.0568 | 0.0586 | 0.0604 | 0.0622 | 0.064 | 0.0659 | 0.0677 | 0.0695 | 0.0713 | 0.0731 | 0.0749 | 0.0767 | 0.0786 | 0.0804 | 0.0822 | 0.084 |
| Propyl Acetate | 0.1836 | 0.1934 | 0.2012 | 0.2109 | 0.2207 | 0.2305 | 0.2402 | 0.25 | 0.2598 | 0.2695 | 0.2793 | 0.2891 | 0.2988 | 0.3086 | 0.3184 | 0.3281 |
| MIBK | 0.0409 | 0.043 | 0.045 | 0.0471 | 0.0492 | 0.0512 | 0.0533 | 0.0554 | 0.0574 | 0.0595 | 0.0616 | 0.0636 | 0.0657 | 0.0678 | 0.0698 | 0.0719 |
| Lube oil | 6.7E-05 | 7E-05 | 7E-05 | 8E-05 | 8E-05 | 8E-05 | 9E-05 | 9E-05 | 9E-05 | 1E-04 | 1E-04 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Light and Heavy Cycle Oils | 6.7E-05 | 7E-05 | 7E-05 | 8E-05 | 8E-05 | 8E-05 | 9E-05 | 9E-05 | 9E-05 | 1E-04 | 1E-04 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Residual Fuel | 0.00203 | 0.0021 | 0.0022 | 0.0023 | 0.0024 | 0.0025 | 0.0026 | 0.0027 | 0.0028 | 0.0029 | 0.003 | 0.0031 | 0.0033 | 0.0034 | 0.0035 | 0.0036 |
| Marine Residual Fuel | 0.01332 | 0.014 | 0.0147 | 0.0153 | 0.016 | 0.0167 | 0.0173 | 0.018 | 0.0186 | 0.0193 | 0.02 | 0.0206 | 0.0213 | 0.022 | 0.0226 | 0.0233 |
| No. 6 Fuel Oil | 0.00002 | 2E-05 | 2E-05 | 2E-05 | 2E-05 | 3E-05 | 3E-05 | 3E-05 | 3E-05 | 3E-05 | 3E-05 | 3E-05 | 3E-05 | 3E-05 | 3E-05 | 4E-05 |

| **Temperature:** | **56** | **57** | **58** | **59** | **60** | **61** | **62** | **63** | **64** | **65** | **66** | **67** | **68** | **69** | **70** | **71** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| heptanes | 0.487 | 0.5005 | 0.514 | 0.5275 | 0.541 | 0.5604 | 0.5798 | 0.5992 | 0.6186 | 0.638 | 0.6574 | 0.6768 | 0.6962 | 0.7156 | 0.735 | 0.7582 |
| n-decane | 0.0143 | 0.0152 | 0.016 | 0.0168 | 0.0177 | 0.0185 | 0.0193 | 0.021 | 0.0227 | 0.0243 | 0.026 | 0.0277 | 0.0293 | 0.031 | 0.0327 | 0.0343 |
| 1-heptene | 0.5332 | 0.5494 | 0.5657 | 0.582 | 0.5982 | 0.6145 | 0.6308 | 0.6471 | 0.6633 | 0.6796 | 0.6959 | 0.7121 | 0.7284 | 0.7447 | 0.7609 | 0.7735 |
| hexane | 1.7056 | 1.7482 | 1.7908 | 1.8334 | 1.876 | 1.932 | 1.988 | 2.044 | 2.1 | 2.156 | 2.212 | 2.268 | 2.324 | 2.38 | 2.436 | 2.4979 |
| nonene | 0.1365 | 0.1374 | 0.1384 | 0.1394 | 0.1403 | 0.1413 | 0.1423 | 0.1432 | 0.1442 | 0.1452 | 0.1461 | 0.1471 | 0.1481 | 0.149 | 0.15 | 0.151 |
| methanol | 1.2496 | 1.2902 | 1.3308 | 1.3714 | 1.412 | 1.4661 | 1.5202 | 1.5743 | 1.6284 | 1.6825 | 1.7366 | 1.7907 | 1.8448 | 1.8989 | 1.953 | 2.0187 |
| ethanol | 0.5338 | 0.5551 | 0.5764 | 0.5977 | 0.619 | 0.6441 | 0.6692 | 0.6943 | 0.7194 | 0.7445 | 0.7696 | 0.7947 | 0.8198 | 0.8449 | 0.87 | 0.9048 |
| isopropanol | 0.4214 | 0.4368 | 0.4522 | 0.4676 | 0.483 | 0.5024 | 0.5218 | 0.5412 | 0.5606 | 0.58 | 0.5994 | 0.6188 | 0.6382 | 0.6576 | 0.677 | 0.7021 |
| butanols (iso Butyl Alcohol) | 0.1198 | 0.1236 | 0.1274 | 0.1312 | 0.135 | 0.1408 | 0.1466 | 0.1524 | 0.1582 | 0.164 | 0.1698 | 0.1756 | 0.1814 | 0.1872 | 0.193 | 0.2008 |
| decanol | 7E-05 | 7E-05 | 8E-05 | 8E-05 | 8E-05 | 8E-05 | 9E-05 | 9E-05 | 9E-05 | 1E-04 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| hexanol | 0.0172 | 0.0183 | 0.0193 | 0.0215 | 0.0236 | 0.0257 | 0.0278 | 0.03 | 0.0321 | 0.0342 | 0.0364 | 0.0385 | 0.0406 | 0.0427 | 0.0449 | 0.047 |
| 2-ethylhexanol | 0.0043 | 0.0044 | 0.0046 | 0.0047 | 0.0049 | 0.0051 | 0.0053 | 0.0055 | 0.0057 | 0.0059 | 0.0061 | 0.0063 | 0.0065 | 0.0068 | 0.007 | 0.0072 |
| Benzene | 1.044 | 1.073 | 1.102 | 1.131 | 1.16 | 1.1948 | 1.2296 | 1.2644 | 1.2992 | 1.334 | 1.3688 | 1.4036 | 1.4384 | 1.4732 | 1.508 | 1.5544 |
| Toluene | 0.2706 | 0.2802 | 0.2898 | 0.2994 | 0.309 | 0.3206 | 0.3322 | 0.3438 | 0.3554 | 0.367 | 0.3786 | 0.3902 | 0.4018 | 0.4134 | 0.425 | 0.4405 |
| acetic acid | 0.159 | 0.1638 | 0.1686 | 0.1734 | 0.1782 | 0.183 | 0.1878 | 0.1926 | 0.1934 | 0.2049 | 0.2135 | 0.2222 | 0.2309 | 0.2395 | 0.2482 | 0.2568 |
| propionic acid | 0.0487 | 0.0505 | 0.0524 | 0.0542 | 0.0561 | 0.0579 | 0.0597 | 0.0616 | 0.0634 | 0.0652 | 0.0671 | 0.0689 | 0.0707 | 0.0726 | 0.0744 | 0.0763 |
| butyric acid | 0.0025 | 0.003 | 0.0034 | 0.0039 | 0.0043 | 0.0048 | 0.0052 | 0.0061 | 0.007 | 0.0078 | 0.0087 | 0.0096 | 0.0105 | 0.0114 | 0.0123 | 0.0131 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crude oil | 0.9123 | 0.9298 | 0.9474 | 0.9649 | 0.9825 | 1.0035 | 1.0246 | 1.0456 | 1.0667 | 1.0877 | 1.1088 | 1.1298 | 1.1509 | 1.1719 | 1.193 | 1.214 |
| crude oil RVP 5 | 2.6 | 2.65 | 2.7 | 2.75 | 2.8 | 2.86 | 2.92 | 2.98 | 3.04 | 3.1 | 3.16 | 3.22 | 3.28 | 3.34 | 3.4 | 3.46 |
| #1 diesel | 0.025 | 0.0259 | 0.0268 | 0.0277 | 0.0286 | 0.0297 | 0.0308 | 0.0319 | 0.033 | 0.0341 | 0.0352 | 0.0363 | 0.0373 | 0.0384 | 0.0395 | 0.0409 |
| #2 diesel | 0.0057 | 0.0059 | 0.0061 | 0.0063 | 0.0065 | 0.0068 | 0.007 | 0.0073 | 0.0075 | 0.0078 | 0.008 | 0.0083 | 0.0085 | 0.0088 | 0.009 | 0.0093 |
| marine diesel oil | 0.0057 | 0.0059 | 0.0061 | 0.0063 | 0.0065 | 0.0068 | 0.007 | 0.0073 | 0.0075 | 0.0078 | 0.008 | 0.0083 | 0.0085 | 0.0088 | 0.009 | 0.0093 |
| gas oil | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gasoline RVP 6 | 2.93 | 2.985 | 3.04 | 3.095 | 3.15 | 3.22 | 3.29 | 3.36 | 3.43 | 3.5 | 3.57 | 3.64 | 3.71 | 3.78 | 3.85 | 3.925 |
| Gasoline RVP 7 | 3.26 | 3.32 | 3.38 | 3.44 | 3.5 | 3.58 | 3.66 | 3.74 | 3.82 | 3.9 | 3.98 | 4.06 | 4.14 | 4.22 | 4.3 | 4.39 |
| Gasoline RVP 7.8 | 3.6449 | 3.7178 | 3.7906 | 3.8635 | 3.9363 | 4.022 | 4.1076 | 4.1933 | 4.279 | 4.3647 | 4.4503 | 4.536 | 4.6217 | 4.7073 | 4.793 | 4.8931 |
| Gasoline RVP 8.3 | 3.9089 | 3.9864 | 4.0638 | 4.1413 | 4.2188 | 4.3098 | 4.4007 | 4.4917 | 4.5826 | 4.6736 | 4.7646 | 4.8555 | 4.9465 | 5.0374 | 5.1284 | 5.2345 |
| Gasoline RVP 10 | 4.8 | 4.9 | 5 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 5.6 | 5.7 | 5.8 | 5.9 | 6 | 6.1 | 6.2 | 6.32 |
| Gasoline RVP 11.5 | 5.6413 | 5.7482 | 5.8551 | 5.9621 | 6.069 | 6.1934 | 6.3178 | 6.4423 | 6.5667 | 6.6911 | 6.8155 | 6.9399 | 7.0644 | 7.1888 | 7.3132 | 7.4571 |
| Gasoline RVP 13 | 6.42 | 6.54 | 6.66 | 6.78 | 6.9 | 7.04 | 7.18 | 7.32 | 7.46 | 7.6 | 7.74 | 7.88 | 8.02 | 8.16 | 8.3 | 8.46 |
| kerosene (Fuel Oil #1) | 0.0258 | 0.0267 | 0.0275 | 0.0284 | 0.0292 | 0.0301 | 0.031 | 0.0318 | 0.0327 | 0.0335 | 0.0344 | 0.0353 | 0.0361 | 0.037 | 0.0378 | 0.0392 |
| jet kerosene (Jet A) | 0.0075 | 0.0078 | 0.008 | 0.0083 | 0.0085 | 0.0088 | 0.009 | 0.0093 | 0.0095 | 0.0098 | 0.01 | 0.0103 | 0.0105 | 0.0108 | 0.011 | 0.0114 |
| jet naphtha (JP-4) | 1.18 | 1.21 | 1.24 | 1.27 | 1.3 | 1.33 | 1.36 | 1.39 | 1.42 | 1.45 | 1.48 | 1.51 | 1.54 | 1.57 | 1.6 | 1.63 |
| Naphtha | 0.1734 | 0.1755 | 0.1776 | 0.1798 | 0.1819 | 0.184 | 0.1861 | 0.1882 | 0.1903 | 0.1924 | 0.1945 | 0.1967 | 0.1988 | 0.2009 | 0.203 | 0.2051 |
| Coker gas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cat Gas | 1.18 | 1.21 | 1.24 | 1.27 | 1.3 | 1.33 | 1.36 | 1.39 | 1.42 | 1.45 | 1.48 | 1.51 | 1.54 | 1.57 | 1.6 | 1.63 |
| Alkylates | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **Temperature:** | **56** | **57** | **58** | **59** | **60** | **61** | **62** | **63** | **64** | **65** | **66** | **67** | **68** | **69** | **70** | **71** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Styrene | 0.0829 | 0.0847 | 0.0864 | 0.0881 | 0.0898 | 0.0915 | 0.0932 | 0.095 | 0.0967 | 0.1011 | 0.1053 | 0.1094 | 0.1136 | 0.1178 | 0.122 | 0.1262 |
| Cumene | 0.0537 | 0.0555 | 0.0573 | 0.0591 | 0.0609 | 0.0627 | 0.0645 | 0.0663 | 0.068 | 0.0698 | 0.0716 | 0.0734 | 0.0752 | 0.077 | 0.0788 | 0.0806 |
| MEK | 1.0906 | 1.1177 | 1.1448 | 1.1719 | 1.199 | 1.228 | 1.257 | 1.286 | 1.315 | 1.344 | 1.373 | 1.402 | 1.431 | 1.46 | 1.489 | 1.547 |
| MTBE | 3.7272 | 3.8181 | 3.909 | 3.9998 | 4.0907 | 4.1556 | 4.2206 | 4.2855 | 4.3504 | 4.4154 | 4.4803 | 4.5452 | 4.6101 | 4.6751 | 4.74 | 4.8984 |
| Butyl Acrylate | 0.0645 | 0.0663 | 0.068 | 0.0698 | 0.0716 | 0.0734 | 0.0752 | 0.077 | 0.0788 | 0.0806 | 0.0824 | 0.0842 | 0.0859 | 0.0877 | 0.0895 | 0.0913 |
| Vinyl Acetate | 1.172 | 1.203 | 1.234 | 1.265 | 1.296 | 1.3385 | 1.381 | 1.4235 | 1.466 | 1.5085 | 1.551 | 1.5935 | 1.636 | 1.6785 | 1.721 | 1.7751 |
| Xylene | 0.0858 | 0.0876 | 0.0894 | 0.0912 | 0.0931 | 0.0949 | 0.0967 | 0.1014 | 0.106 | 0.1107 | 0.1154 | 0.12 | 0.1247 | 0.1294 | 0.134 | 0.1387 |
| Propyl Acetate | 0.3379 | 0.3477 | 0.3574 | 0.3672 | 0.377 | 0.3867 | 0.4042 | 0.421 | 0.4378 | 0.4546 | 0.4714 | 0.4881 | 0.5049 | 0.5217 | 0.5385 | 0.5553 |
| MIBK | 0.074 | 0.076 | 0.0781 | 0.0802 | 0.0822 | 0.0843 | 0.0864 | 0.0884 | 0.0905 | 0.0926 | 0.0946 | 0.0967 | 0.1022 | 0.1072 | 0.1123 | 0.1174 |
| Lube oil | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| Light and Heavy Cycle Oils | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| Residual Fuel | 0.0037 | 0.0038 | 0.0039 | 0.004 | 0.0041 | 0.0043 | 0.0045 | 0.0047 | 0.0049 | 0.0051 | 0.0053 | 0.0055 | 0.0057 | 0.0059 | 0.0061 | 0.0064 |
| Marine Residual Fuel | 0.024 | 0.0246 | 0.0253 | 0.026 | 0.0266 | 0.028 | 0.0293 | 0.0306 | 0.032 | 0.0333 | 0.0347 | 0.036 | 0.0373 | 0.0387 | 0.04 | 0.042 |
| No. 6 Fuel Oil | 4E-05 | 4E-05 | 4E-05 | 4E-05 | 4E-05 | 4E-05 | 4E-05 | 5E-05 | 5E-05 | 5E-05 | 5E-05 | 5E-05 | 6E-05 | 6E-05 | 6E-05 | 6E-05 |

| **Temperature:** | **72** | **73** | **74** | **75** | **76** | **77** | **78** | **79** | **80** | **81** | **82** | **83** | **84** | **85** | **86** | **87** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| heptanes | 0.7814 | 0.8046 | 0.8278 | 0.851 | 0.8742 | 0.8974 | 0.9206 | 0.9438 | 0.967 | 0.9941 | 1.0212 | 1.0483 | 1.0754 | 1.1025 | 1.1296 | 1.1567 |
| n-decane | 0.036 | 0.0377 | 0.0393 | 0.041 | 0.0427 | 0.0443 | 0.046 | 0.0476 | 0.0493 | 0.051 | 0.0526 | 0.0543 | 0.056 | 0.0576 | 0.0593 | 0.061 |
| 1-heptene | 0.8064 | 0.8317 | 0.857 | 0.8822 | 0.9075 | 0.9328 | 0.958 | 0.9833 | 1.0086 | 1.0339 | 1.0591 | 1.0844 | 1.1097 | 1.1349 | 1.1602 | 1.1982 |
| hexane | 2.5598 | 2.6217 | 2.6836 | 2.7455 | 2.8074 | 2.8693 | 2.9312 | 2.9931 | 3.055 | 3.1401 | 3.2252 | 3.3103 | 3.3954 | 3.4805 | 3.5656 | 3.6507 |
| nonene | 0.1519 | 0.1529 | 0.1539 | 0.1548 | 0.1558 | 0.1568 | 0.1577 | 0.1587 | 0.1597 | 0.1606 | 0.1616 | 0.1626 | 0.1635 | 0.1645 | 0.1655 | 0.1664 |
| methanol | 2.0844 | 2.1501 | 2.2158 | 2.2815 | 2.3472 | 2.4129 | 2.4786 | 2.5443 | 2.61 | 2.6951 | 2.7802 | 2.8653 | 2.9504 | 3.0355 | 3.1206 | 3.2057 |
| ethanol | 0.9396 | 0.9744 | 1.0092 | 1.044 | 1.0788 | 1.1136 | 1.1484 | 1.1832 | 1.218 | 1.2644 | 1.3108 | 1.3572 | 1.4036 | 1.45 | 1.4964 | 1.5428 |
| isopropanol | 0.7272 | 0.7523 | 0.7774 | 0.8025 | 0.8276 | 0.8527 | 0.8778 | 0.9029 | 0.928 | 0.9648 | 1.0016 | 1.0384 | 1.0752 | 1.112 | 1.1488 | 1.1856 |
| butanols (iso Butyl Alcohol) | 0.2086 | 0.2164 | 0.2242 | 0.232 | 0.2398 | 0.2476 | 0.2554 | 0.2632 | 0.271 | 0.2826 | 0.2942 | 0.3058 | 0.3174 | 0.329 | 0.3406 | 0.3522 |
| decanol | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| hexanol | 0.0491 | 0.0512 | 0.0534 | 0.0555 | 0.0576 | 0.0597 | 0.0619 | 0.064 | 0.0661 | 0.0683 | 0.0704 | 0.0725 | 0.0746 | 0.0768 | 0.0789 | 0.081 |
| 2-ethylhexanol | 0.0075 | 0.0078 | 0.0081 | 0.0084 | 0.0086 | 0.0089 | 0.0092 | 0.0095 | 0.0098 | 0.0102 | 0.0106 | 0.011 | 0.0114 | 0.0118 | 0.0123 | 0.0127 |
| Benzene | 1.6008 | 1.6472 | 1.6936 | 1.74 | 1.7864 | 1.8328 | 1.8792 | 1.9256 | 1.972 | 2.0358 | 2.0996 | 2.1634 | 2.2272 | 2.291 | 2.3548 | 2.4186 |
| Toluene | 0.456 | 0.4715 | 0.487 | 0.5025 | 0.518 | 0.5335 | 0.549 | 0.5645 | 0.58 | 0.5993 | 0.6186 | 0.6379 | 0.6572 | 0.6765 | 0.6958 | 0.7151 |
| acetic acid | 0.2655 | 0.2742 | 0.2828 | 0.2915 | 0.3001 | 0.3088 | 0.3175 | 0.3261 | 0.3348 | 0.3434 | 0.3521 | 0.3608 | 0.3694 | 0.3781 | 0.3867 | 0.4031 |
| propionic acid | 0.0781 | 0.0799 | 0.0818 | 0.0836 | 0.0854 | 0.0873 | 0.0891 | 0.0909 | 0.0928 | 0.0946 | 0.0967 | 0.1013 | 0.1059 | 0.1105 | 0.115 | 0.1196 |
| butyric acid | 0.014 | 0.0149 | 0.0158 | 0.0167 | 0.0176 | 0.0185 | 0.0193 | 0.0211 | 0.0229 | 0.0246 | 0.0264 | 0.0282 | 0.0299 | 0.0317 | 0.0335 | 0.0352 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crude oil | 1.2351 | 1.2561 | 1.2772 | 1.2982 | 1.3193 | 1.3404 | 1.3614 | 1.3825 | 1.4035 | 1.4316 | 1.4596 | 1.4877 | 1.5158 | 1.5439 | 1.5719 | 1.6 |
| crude oil RVP 5 | 3.52 | 3.58 | 3.64 | 3.7 | 3.76 | 3.82 | 3.88 | 3.94 | 4 | 4.08 | 4.16 | 4.24 | 4.32 | 4.4 | 4.48 | 4.56 |
| #1 diesel | 0.0422 | 0.0435 | 0.0448 | 0.0461 | 0.0475 | 0.0488 | 0.0501 | 0.0514 | 0.0527 | 0.0545 | 0.0562 | 0.058 | 0.0598 | 0.0615 | 0.0633 | 0.065 |
| #2 diesel | 0.0096 | 0.0099 | 0.0102 | 0.0105 | 0.0108 | 0.0111 | 0.0114 | 0.0117 | 0.012 | 0.0124 | 0.0128 | 0.0132 | 0.0136 | 0.014 | 0.0144 | 0.0148 |
| marine diesel oil | 0.0096 | 0.0099 | 0.0102 | 0.0105 | 0.0108 | 0.0111 | 0.0114 | 0.0117 | 0.012 | 0.0124 | 0.0128 | 0.0132 | 0.0136 | 0.014 | 0.0144 | 0.0148 |
| gas oil | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **Temperature:** | **72** | **73** | **74** | **75** | **76** | **77** | **78** | **79** | **80** | **81** | **82** | **83** | **84** | **85** | **86** | **87** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gasoline RVP 6 | 4 | 4.075 | 4.15 | 4.225 | 4.3 | 4.375 | 4.45 | 4.525 | 4.6 | 4.69 | 4.78 | 4.87 | 4.96 | 5.05 | 5.14 | 5.23 |
| Gasoline RVP 7 | 4.48 | 4.57 | 4.66 | 4.75 | 4.84 | 4.93 | 5.02 | 5.11 | 5.2 | 5.3 | 5.4 | 5.5 | 5.6 | 5.7 | 5.8 | 5.9 |
| Gasoline RVP 7.8 | 4.9931 | 5.0932 | 5.1933 | 5.2934 | 5.3934 | 5.4935 | 5.5936 | 5.6936 | 5.7937 | 5.9099 | 6.026 | 6.1422 | 6.2583 | 6.3745 | 6.4906 | 6.6068 |
| Gasoline RVP 8.3 | 5.3405 | 5.4466 | 5.5527 | 5.6588 | 5.7648 | 5.8709 | 5.977 | 6.083 | 6.1891 | 6.312 | 6.435 | 6.5579 | 6.6808 | 6.8038 | 6.9267 | 7.0496 |
| Gasoline RVP 10 | 6.44 | 6.56 | 6.68 | 6.8 | 6.92 | 7.04 | 7.16 | 7.28 | 7.4 | 7.54 | 7.68 | 7.82 | 7.96 | 8.1 | 8.24 | 8.38 |
| Gasoline RVP 11.5 | 7.6009 | 7.7448 | 7.8887 | 8.0326 | 8.1764 | 8.3203 | 8.4642 | 8.608 | 8.7519 | 8.9172 | 9.0826 | 9.2479 | 9.4133 | 9.5786 | 9.7439 | 9.9093 |
| Gasoline RVP 13 | 8.62 | 8.78 | 8.94 | 9.1 | 9.26 | 9.42 | 9.58 | 9.74 | 9.9 | 10.08 | 10.26 | 10.44 | 10.62 | 10.8 | 10.98 | 11.16 |
| kerosene (Fuel Oil #1) | 0.0406 | 0.042 | 0.0433 | 0.0447 | 0.0461 | 0.0475 | 0.0488 | 0.0502 | 0.0516 | 0.0537 | 0.0557 | 0.0578 | 0.0599 | 0.0619 | 0.064 | 0.066 |
| jet kerosene (Jet A) | 0.0118 | 0.0122 | 0.0126 | 0.013 | 0.0134 | 0.0138 | 0.0142 | 0.0146 | 0.015 | 0.0156 | 0.0162 | 0.0168 | 0.0174 | 0.018 | 0.0186 | 0.0192 |
| jet naphtha (JP-4) | 1.66 | 1.69 | 1.72 | 1.75 | 1.78 | 1.81 | 1.84 | 1.87 | 1.9 | 1.95 | 2 | 2.05 | 2.1 | 2.15 | 2.2 | 2.25 |
| Naphtha | 0.2072 | 0.2093 | 0.2115 | 0.2136 | 0.2157 | 0.2178 | 0.2199 | 0.222 | 0.2241 | 0.2262 | 0.2284 | 0.2305 | 0.2326 | 0.2347 | 0.2368 | 0.2389 |
| Coker gas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cat Gas | 1.66 | 1.69 | 1.72 | 1.75 | 1.78 | 1.81 | 1.84 | 1.87 | 1.9 | 1.95 | 2 | 2.05 | 2.1 | 2.15 | 2.2 | 2.25 |
| Alkylates | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Styrene | 0.1304 | 0.1346 | 0.1388 | 0.143 | 0.1472 | 0.1514 | 0.1556 | 0.1598 | 0.164 | 0.1682 | 0.1724 | 0.1766 | 0.1808 | 0.185 | 0.1892 | 0.1934 |
| Cumene | 0.0824 | 0.0842 | 0.0859 | 0.0877 | 0.0895 | 0.0913 | 0.0931 | 0.0949 | 0.0967 | 0.1014 | 0.106 | 0.1107 | 0.1154 | 0.12 | 0.1247 | 0.1294 |
| MEK | 1.605 | 1.663 | 1.721 | 1.779 | 1.837 | 1.895 | 1.953 | 2.011 | 2.069 | 2.1289 | 2.1888 | 2.2487 | 2.3086 | 2.3685 | 2.4284 | 2.4883 |
| MTBE | 5.0569 | 5.2153 | 5.3738 | 5.5322 | 5.6907 | 5.8491 | 6.0076 | 6.166 | 6.3245 | 6.4712 | 6.6179 | 6.7647 | 6.9114 | 7.0582 | 7.2049 | 7.3517 |
| Butyl Acrylate | 0.0931 | 0.0949 | 0.0967 | 0.0994 | 0.1038 | 0.1083 | 0.1128 | 0.1173 | 0.1218 | 0.1262 | 0.1307 | 0.1352 | 0.1397 | 0.1441 | 0.1486 | 0.1531 |
| Vinyl Acetate | 1.8292 | 1.8833 | 1.9374 | 1.9915 | 2.0456 | 2.0997 | 2.1538 | 2.2079 | 2.262 | 2.3471 | 2.4322 | 2.5173 | 2.6024 | 2.6875 | 2.7726 | 2.8577 |
| Xylene | 0.1434 | 0.1481 | 0.1527 | 0.1574 | 0.1621 | 0.1667 | 0.1714 | 0.1761 | 0.1807 | 0.1854 | 0.1901 | 0.1934 | 0.2018 | 0.2102 | 0.2186 | 0.227 |
| Propyl Acetate | 0.5721 | 0.5888 | 0.6056 | 0.6224 | 0.6392 | 0.656 | 0.6728 | 0.6895 | 0.7063 | 0.7231 | 0.7399 | 0.7567 | 0.7735 | 0.7997 | 0.8259 | 0.8521 |
| MIBK | 0.1224 | 0.1275 | 0.1326 | 0.1376 | 0.1427 | 0.1478 | 0.1528 | 0.1579 | 0.163 | 0.168 | 0.1731 | 0.1782 | 0.1832 | 0.1883 | 0.1934 | 0.2033 |
| Lube oil | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0004 | 0.0004 | 0.0004 | 0.0004 |
| Light and Heavy Cycle Oils | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0004 | 0.0004 | 0.0004 | 0.0004 |
| Residual Fuel | 0.0067 | 0.007 | 0.0073 | 0.0076 | 0.0079 | 0.0082 | 0.0085 | 0.0088 | 0.0091 | 0.0095 | 0.01 | 0.0104 | 0.0108 | 0.0112 | 0.0116 | 0.012 |
| Marine Residual Fuel | 0.044 | 0.046 | 0.048 | 0.05 | 0.052 | 0.054 | 0.056 | 0.0579 | 0.0599 | 0.0626 | 0.0653 | 0.0679 | 0.0706 | 0.0733 | 0.0759 | 0.0786 |
| No. 6 Fuel Oil | 7E-05 | 7E-05 | 7E-05 | 8E-05 | 8E-05 | 8E-05 | 8E-05 | 9E-05 | 9E-05 | 9E-05 | 1E-04 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |

| **Temperature:** | **88** | **89** | **90** | **91** | **92** | **93** | **94** | **95** | **96** | **97** | **98** | **99** | **100** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| heptanes | 1.1838 | 1.2109 | 1.238 | 1.2728 | 1.3076 | 1.3424 | 1.3772 | 1.412 | 1.4468 | 1.4816 | 1.5164 | 1.5512 | 1.586 |
| n-decane | 0.0626 | 0.0643 | 0.066 | 0.0676 | 0.0693 | 0.071 | 0.0726 | 0.0743 | 0.076 | 0.0776 | 0.0793 | 0.081 | 0.0826 |
| 1-heptene | 1.2362 | 1.2742 | 1.3122 | 1.3502 | 1.3882 | 1.4262 | 1.4642 | 1.5022 | 1.5402 | 1.5782 | 1.6162 | 1.6542 | 1.6922 |
| hexane | 3.7358 | 3.8209 | 3.906 | 4.0046 | 4.1032 | 4.2018 | 4.3004 | 4.399 | 4.4976 | 4.5962 | 4.6948 | 4.7934 | 4.892 |
| nonene | 0.1674 | 0.1684 | 0.1693 | 0.1703 | 0.1713 | 0.1722 | 0.1732 | 0.1742 | 0.1751 | 0.1761 | 0.1771 | 0.178 | 0.179 |
| methanol | 3.2908 | 3.3759 | 3.461 | 3.5674 | 3.6738 | 3.7802 | 3.8866 | 3.993 | 4.0994 | 4.2058 | 4.3122 | 4.4186 | 4.525 |
| ethanol | 1.5892 | 1.6356 | 1.682 | 1.7458 | 1.8096 | 1.8734 | 1.9372 | 2.001 | 2.0648 | 2.1286 | 2.1924 | 2.2562 | 2.32 |
| isopropanol | 1.2224 | 1.2592 | 1.296 | 1.3443 | 1.3926 | 1.4409 | 1.4892 | 1.5375 | 1.5858 | 1.6341 | 1.6824 | 1.7307 | 1.779 |
| butanols (iso Butyl Alcohol) | 0.3638 | 0.3754 | 0.387 | 0.4024 | 0.4178 | 0.4332 | 0.4486 | 0.464 | 0.4794 | 0.4948 | 0.5102 | 0.5256 | 0.541 |
| decanol | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |
| hexanol | 0.0831 | 0.0853 | 0.0874 | 0.0895 | 0.0917 | 0.0938 | 0.0959 | 0.0967 | 0.1019 | 0.1072 | 0.1125 | 0.1177 | 0.123 |
| 2-ethylhexanol | 0.0131 | 0.0135 | 0.0139 | 0.0145 | 0.015 | 0.0156 | 0.0161 | 0.0167 | 0.0173 | 0.0178 | 0.0184 | 0.0189 | 0.0195 |
| Benzene | 2.4824 | 2.5462 | 2.61 | 2.6777 | 2.7454 | 2.8131 | 2.8808 | 2.9485 | 3.0162 | 3.0839 | 3.1516 | 3.2193 | 3.287 |
| Toluene | 0.7344 | 0.7537 | 0.773 | 0.7963 | 0.8196 | 0.8429 | 0.8662 | 0.8895 | 0.9128 | 0.9361 | 0.9594 | 0.9827 | 1.006 |
| acetic acid | 0.4195 | 0.4359 | 0.4523 | 0.4687 | 0.4851 | 0.5015 | 0.5179 | 0.5343 | 0.5507 | 0.5671 | 0.5835 | 0.5999 | 0.6163 |
| propionic acid | 0.1242 | 0.1288 | 0.1334 | 0.138 | 0.1426 | 0.1472 | 0.1518 | 0.1564 | 0.1609 | 0.1655 | 0.1701 | 0.1747 | 0.1793 |
| butyric acid | 0.037 | 0.0388 | 0.0406 | 0.0423 | 0.0441 | 0.0459 | 0.0476 | 0.0494 | 0.0512 | 0.0529 | 0.0547 | 0.0565 | 0.0582 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crude oil | 1.6281 | 1.6561 | 1.6842 | 1.7158 | 1.7474 | 1.7789 | 1.8105 | 1.8421 | 1.8737 | 1.9053 | 1.9368 | 1.9684 | 2 |
| crude oil RVP 5 | 4.64 | 4.72 | 4.8 | 4.89 | 4.98 | 5.07 | 5.16 | 5.25 | 5.34 | 5.43 | 5.52 | 5.61 | 5.7 |
| #1 diesel | 0.0668 | 0.0685 | 0.0703 | 0.0729 | 0.0756 | 0.0782 | 0.0808 | 0.0835 | 0.0861 | 0.0888 | 0.0914 | 0.094 | 0.0967 |
| #2 diesel | 0.0152 | 0.0156 | 0.016 | 0.0166 | 0.0172 | 0.0178 | 0.0184 | 0.019 | 0.0196 | 0.0202 | 0.0208 | 0.0214 | 0.022 |
| marine diesel oil | 0.0152 | 0.0156 | 0.016 | 0.0166 | 0.0172 | 0.0178 | 0.0184 | 0.019 | 0.0196 | 0.0202 | 0.0208 | 0.0214 | 0.022 |
| gas oil | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gasoline RVP 6 | 5.32 | 5.41 | 5.5 | 5.605 | 5.71 | 5.815 | 5.92 | 6.025 | 6.13 | 6.235 | 6.34 | 6.445 | 6.55 |
| Gasoline RVP 7 | 6 | 6.1 | 6.2 | 6.32 | 6.44 | 6.56 | 6.68 | 6.8 | 6.92 | 7.04 | 7.16 | 7.28 | 7.4 |
| Gasoline RVP 7.8 | 6.7229 | 6.8391 | 6.9552 | 7.0892 | 7.2232 | 7.3572 | 7.4912 | 7.6252 | 7.7592 | 7.8932 | 8.0272 | 8.1612 | 8.2952 |
| Gasoline RVP 8.3 | 7.1725 | 7.2955 | 7.4184 | 7.56 | 7.7016 | 7.8432 | 7.9848 | 8.1264 | 8.268 | 8.4096 | 8.5512 | 8.6928 | 8.8344 |
| Gasoline RVP 10 | 8.52 | 8.66 | 8.8 | 8.97 | 9.14 | 9.31 | 9.48 | 9.65 | 9.82 | 9.99 | 10.16 | 10.33 | 10.5 |
| Gasoline RVP 11.5 | 10.075 | 10.24 | 10.405 | 10.594 | 10.783 | 10.972 | 11.161 | 11.35 | 11.539 | 11.728 | 11.917 | 12.106 | 12.295 |
| Gasoline RVP 13 | 11.34 | 11.52 | 11.7 | 11.91 | 12.12 | 12.33 | 12.54 | 12.75 | 12.96 | 13.17 | 13.38 | 13.59 | 13.8 |
| kerosene (Fuel Oil #1) | 0.0681 | 0.0702 | 0.0722 | 0.075 | 0.0778 | 0.0806 | 0.0833 | 0.0861 | 0.0889 | 0.0917 | 0.0944 | 0.0972 | 0.1 |
| jet kerosene (Jet A) | 0.0198 | 0.0204 | 0.021 | 0.0218 | 0.0226 | 0.0234 | 0.0242 | 0.025 | 0.0258 | 0.0266 | 0.0274 | 0.0282 | 0.029 |
| jet naphtha (JP-4) | 2.3 | 2.35 | 2.4 | 2.43 | 2.46 | 2.49 | 2.52 | 2.55 | 2.58 | 2.61 | 2.64 | 2.67 | 2.7 |
| Naphtha | 0.241 | 0.2431 | 0.2453 | 0.2474 | 0.2495 | 0.2516 | 0.2537 | 0.2558 | 0.2579 | 0.26 | 0.2622 | 0.2643 | 0.2664 |
| Coker gas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cat Gas | 2.3 | 2.35 | 2.4 | 2.43 | 2.46 | 2.49 | 2.52 | 2.55 | 2.58 | 2.61 | 2.64 | 2.67 | 2.7 |
| Alkylates | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **Temperature:** | **88** | **89** | **90** | **91** | **92** | **93** | **94** | **95** | **96** | **97** | **98** | **99** | **100** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assume non-volatile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Styrene | 0.2012 | 0.2089 | 0.2167 | 0.2245 | 0.2323 | 0.2401 | 0.2479 | 0.2556 | 0.2634 | 0.2712 | 0.279 | 0.2868 | 0.2946 |
| Cumene | 0.134 | 0.1387 | 0.1434 | 0.1481 | 0.1527 | 0.1574 | 0.1621 | 0.1667 | 0.1714 | 0.1761 | 0.1807 | 0.1854 | 0.1901 |
| MEK | 2.5482 | 2.6081 | 2.668 | 2.7357 | 2.8034 | 2.8711 | 2.9388 | 3.0065 | 3.0742 | 3.1419 | 3.2096 | 3.2773 | 3.345 |
| MTBE | 7.4984 | 7.6452 | 7.7919 | 7.9388 | 8.0858 | 8.2327 | 8.3797 | 8.5266 | 8.6736 | 8.8205 | 8.9675 | 9.1144 | 9.2614 |
| Butyl Acrylate | 0.1576 | 0.162 | 0.1665 | 0.171 | 0.1755 | 0.1799 | 0.1844 | 0.1889 | 0.1934 | 0.2016 | 0.2098 | 0.218 | 0.2262 |
| Vinyl Acetate | 2.9428 | 3.0279 | 3.113 | 3.2039 | 3.2948 | 3.3857 | 3.4766 | 3.5675 | 3.6584 | 3.7493 | 3.8402 | 3.9311 | 4.022 |
| Xylene | 0.2354 | 0.2438 | 0.2522 | 0.2606 | 0.269 | 0.2774 | 0.2858 | 0.2942 | 0.3026 | 0.311 | 0.3194 | 0.3278 | 0.3362 |
| Propyl Acetate | 0.8783 | 0.9045 | 0.9307 | 0.9569 | 0.9831 | 1.0093 | 1.0355 | 1.0617 | 1.0879 | 1.1141 | 1.1403 | 1.1665 | 1.1927 |
| MIBK | 0.2133 | 0.2232 | 0.2332 | 0.2431 | 0.2531 | 0.263 | 0.273 | 0.2829 | 0.2929 | 0.3028 | 0.3128 | 0.3227 | 0.3327 |
| Lube oil | 0.0004 | 0.0004 | 0.0004 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0006 |
| Light and Heavy Cycle Oils | 0.0004 | 0.0004 | 0.0004 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0006 |
| Residual Fuel | 0.0124 | 0.0128 | 0.0132 | 0.0138 | 0.0144 | 0.015 | 0.0156 | 0.0163 | 0.0169 | 0.0175 | 0.0181 | 0.0187 | 0.0193 |
| Marine Residual Fuel | 0.0813 | 0.0839 | 0.0866 | 0.0906 | 0.0946 | 0.0986 | 0.1026 | 0.1066 | 0.1106 | 0.1146 | 0.1185 | 0.1225 | 0.1265 |
| No. 6 Fuel Oil | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |

# Appendix B
# Pressure Calculation for Low Pressure Tanks

## *Houston*

**Houston Area**
**Evaporation Loss from Low Pressure Tanks**
This formula determines the gauge pressure at which no emissions will occur, given variable inputs for ambient temperature, solar insolation, trip duration, and product vapor pressure.
This formula is based on API Bulletin 2516 - "Evaporation Loss From Low-Pressure Storage Tanks"
**Reference:**
American Petroleum Institute, 2006. API Bulletin 2516 - "Evaporation Loss From Low-Pressure Storage Tanks". March 1962, Reaffirmed February 2006.

P2 = (t2/t1) x (Pa + P1 - p1 ) - (Pa - p2)
where:
P2 = gauge pressure at which the pressure vent opens
Pa = atmospheric pressure at sea level = 14.7
P1 = gauge pressure at which the vacuum vent opens
p1 = true vapor pressure at min. surface temp. (deg. F), in psia
p2 = true vapor pressure at max. surface temp. (deg. F), in psia
t1 = minimum avg. vapor space temperature (degrees R)
t2 = maximum avg. vapor space temperature (degrees R)

| | | | |
|---|---|---|---|
| P2 | | | |
| Pa | 14.7 | 14.7 | 14.7 |
| P1 | 0.0625 | 0.0625 | 0.0625 |
| p1 | varies | varies | varies |
| p2 | varies | varies | varies |
| t1 | varies | varies | varies |
| t2 | varies | varies | varies |

**Assumptions:**
temperature for p1 and t1 = average ambient air temp

| | | Values for P2 in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.245 | 0.263 | 0.278 | 0.278 | 0.306 | 0.287 | 0.314 | 0.287 | 0.306 | 0.293 | 0.268 | 0.247 |
| | n-decane | 0.237 | 0.257 | 0.268 | 0.269 | 0.274 | 0.275 | 0.277 | 0.276 | 0.276 | 0.282 | 0.256 | 0.240 |
| | 1-heptene | 0.247 | 0.266 | 0.274 | 0.274 | 0.309 | 0.284 | 0.310 | 0.285 | 0.310 | 0.282 | 0.264 | 0.249 |
| | hexane | 0.261 | 0.277 | 0.295 | 0.292 | 0.356 | 0.314 | 0.397 | 0.313 | 0.355 | 0.306 | 0.287 | 0.263 |
| | nonene | 0.236 | 0.255 | 0.265 | 0.267 | 0.271 | 0.273 | 0.274 | 0.274 | 0.273 | 0.279 | 0.255 | 0.238 |
| Alcohols | methanol | 0.265 | 0.281 | 0.299 | 0.297 | 0.371 | 0.320 | 0.404 | 0.319 | 0.369 | 0.317 | 0.291 | 0.266 |
| | ethanol | 0.253 | 0.271 | 0.282 | 0.282 | 0.326 | 0.302 | 0.348 | 0.302 | 0.326 | 0.302 | 0.273 | 0.255 |
| | isopropanol | 0.248 | 0.266 | 0.278 | 0.279 | 0.310 | 0.297 | 0.334 | 0.297 | 0.311 | 0.296 | 0.269 | 0.250 |
| | butanols (iso Butyl Alcohol) | 0.239 | 0.258 | 0.270 | 0.271 | 0.284 | 0.282 | 0.294 | 0.282 | 0.285 | 0.285 | 0.260 | 0.241 |
| | decanol | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| | hexanol | 0.237 | 0.257 | 0.268 | 0.270 | 0.275 | 0.275 | 0.278 | 0.276 | 0.277 | 0.282 | 0.257 | 0.240 |
| | 2-ethylhexanol | 0.237 | 0.256 | 0.266 | 0.268 | 0.272 | 0.274 | 0.276 | 0.275 | 0.274 | 0.281 | 0.256 | 0.239 |
| Benzene/Toluene | Benzene | 0.255 | 0.272 | 0.284 | 0.283 | 0.340 | 0.309 | 0.371 | 0.308 | 0.339 | 0.305 | 0.275 | 0.256 |
| | Toluene | 0.243 | 0.262 | 0.273 | 0.274 | 0.295 | 0.285 | 0.304 | 0.285 | 0.296 | 0.290 | 0.263 | 0.246 |
| Carboxylic Acids | acetic acid | 0.240 | 0.259 | 0.268 | 0.274 | 0.285 | 0.278 | 0.287 | 0.279 | 0.286 | 0.285 | 0.258 | 0.242 |
| | propionic acid | 0.238 | 0.257 | 0.267 | 0.269 | 0.274 | 0.275 | 0.283 | 0.278 | 0.276 | 0.281 | 0.257 | 0.240 |
| | butyric acid | 0.237 | 0.257 | 0.267 | 0.269 | 0.273 | 0.275 | 0.278 | 0.276 | 0.276 | 0.281 | 0.256 | 0.239 |
| Chemical Products NEC | Assume non-volatile | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |

| | | Values for P2 in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Chemical Additives | Assume non-volatile | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| Crude Petroleum | crude oil | 0.244 | 0.262 | 0.273 | 0.273 | 0.295 | 0.282 | 0.310 | 0.282 | 0.296 | 0.284 | 0.264 | 0.246 |
| | crude oil RVP 5 | 0.259 | 0.273 | 0.286 | 0.282 | 0.339 | 0.296 | 0.374 | 0.294 | 0.338 | 0.290 | 0.279 | 0.260 |
| Distillate Fuel Oils | #1 diesel | 0.237 | 0.257 | 0.267 | 0.269 | 0.273 | 0.275 | 0.278 | 0.276 | 0.275 | 0.281 | 0.256 | 0.240 |
| | #2 diesel | 0.237 | 0.256 | 0.266 | 0.268 | 0.272 | 0.274 | 0.275 | 0.275 | 0.274 | 0.281 | 0.256 | 0.239 |
| | marine diesel oil | 0.237 | 0.256 | 0.266 | 0.268 | 0.272 | 0.274 | 0.275 | 0.275 | 0.274 | 0.281 | 0.256 | 0.239 |
| | gas oil | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| Gasoline | Gasoline RVP 6 | 0.260 | 0.273 | 0.291 | 0.286 | 0.362 | 0.297 | 0.385 | 0.295 | 0.360 | 0.299 | 0.284 | 0.261 |
| | Gasoline RVP 7 | 0.262 | 0.274 | 0.296 | 0.290 | 0.384 | 0.298 | 0.396 | 0.296 | 0.382 | 0.307 | 0.290 | 0.262 |
| | Gasoline RVP 7.8 | 0.271 | 0.282 | 0.295 | 0.289 | 0.397 | 0.305 | 0.419 | 0.303 | 0.393 | 0.310 | 0.290 | 0.271 |
| | Gasoline RVP 8.3 | 0.272 | 0.283 | 0.296 | 0.290 | 0.403 | 0.306 | 0.426 | 0.304 | 0.400 | 0.311 | 0.291 | 0.272 |
| | Gasoline RVP 10 | 0.286 | 0.294 | 0.292 | 0.285 | 0.415 | 0.306 | 0.442 | 0.302 | 0.411 | 0.309 | 0.288 | 0.285 |
| | Gasoline RVP 11.5 | 0.283 | 0.290 | 0.303 | 0.294 | 0.445 | 0.312 | 0.473 | 0.307 | 0.440 | 0.316 | 0.301 | 0.282 |
| | Gasoline RVP 13 | 0.288 | 0.293 | 0.307 | 0.296 | 0.463 | 0.310 | 0.485 | 0.305 | 0.456 | 0.318 | 0.305 | 0.287 |
| Kerosene | kerosene (Fuel Oil #1) | 0.237 | 0.257 | 0.267 | 0.268 | 0.274 | 0.275 | 0.278 | 0.276 | 0.275 | 0.281 | 0.256 | 0.240 |
| | jet kerosene (Jet A) | 0.237 | 0.256 | 0.266 | 0.268 | 0.272 | 0.274 | 0.276 | 0.275 | 0.274 | 0.281 | 0.256 | 0.239 |
| | jet naphtha (JP-4) | 0.254 | 0.271 | 0.277 | 0.277 | 0.307 | 0.296 | 0.345 | 0.296 | 0.307 | 0.287 | 0.269 | 0.256 |
| Naphtha and Solvents | Naphtha | 0.237 | 0.256 | 0.266 | 0.267 | 0.273 | 0.273 | 0.276 | 0.274 | 0.274 | 0.280 | 0.255 | 0.239 |
| | Coker gas | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| | Cat Gas | 0.254 | 0.271 | 0.277 | 0.277 | 0.307 | 0.296 | 0.345 | 0.296 | 0.307 | 0.287 | 0.269 | 0.256 |
| | Alkylates | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| | 0 | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| Organic Compounds NEC | Assume non-volatile | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| Other Hydrocarbons | Styrene | 0.237 | 0.257 | 0.267 | 0.271 | 0.278 | 0.276 | 0.281 | 0.277 | 0.279 | 0.283 | 0.256 | 0.240 |
| | Cumene | 0.238 | 0.257 | 0.267 | 0.269 | 0.274 | 0.277 | 0.283 | 0.278 | 0.275 | 0.281 | 0.257 | 0.240 |
| | MEK | 0.252 | 0.269 | 0.278 | 0.277 | 0.362 | 0.303 | 0.362 | 0.303 | 0.361 | 0.316 | 0.269 | 0.254 |
| | MTBE | 0.289 | 0.299 | 0.273 | 0.269 | 0.510 | 0.328 | 0.471 | 0.324 | 0.504 | 0.369 | 0.267 | 0.289 |
| | Butyl Acrylate | 0.238 | 0.257 | 0.267 | 0.269 | 0.279 | 0.277 | 0.282 | 0.278 | 0.281 | 0.281 | 0.256 | 0.240 |
| | Vinyl Acetate | 0.255 | 0.272 | 0.290 | 0.288 | 0.351 | 0.325 | 0.409 | 0.324 | 0.351 | 0.309 | 0.281 | 0.257 |
| | Xylene | 0.237 | 0.257 | 0.269 | 0.271 | 0.279 | 0.276 | 0.289 | 0.281 | 0.280 | 0.283 | 0.256 | 0.240 |
| | Propyl Acetate | 0.243 | 0.262 | 0.277 | 0.278 | 0.296 | 0.280 | 0.307 | 0.281 | 0.297 | 0.289 | 0.260 | 0.245 |
| | MIBK | 0.238 | 0.257 | 0.267 | 0.272 | 0.280 | 0.277 | 0.282 | 0.278 | 0.281 | 0.284 | 0.257 | 0.240 |
| Petroleum Products NEC | Lube oil | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| | Light and Heavy Cycle Oils | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |
| Residual Fuel Oil | Residual Fuel | 0.237 | 0.256 | 0.266 | 0.268 | 0.272 | 0.274 | 0.276 | 0.275 | 0.274 | 0.281 | 0.256 | 0.239 |
| | Marine Residual Fuel | 0.237 | 0.256 | 0.267 | 0.269 | 0.275 | 0.276 | 0.279 | 0.277 | 0.276 | 0.282 | 0.257 | 0.239 |
| | No. 6 Fuel Oil | 0.236 | 0.256 | 0.266 | 0.268 | 0.271 | 0.274 | 0.275 | 0.275 | 0.273 | 0.280 | 0.256 | 0.239 |

**None of these cargos will emit on this 2 hour trip when loaded in a 1 pound barge.**
**No need to model emissions for any of these cargos on this trip length.**

| | | Values for P2 in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.877 | 0.973 | 1.059 | 1.076 | 1.119 | 1.140 | 1.140 | 1.141 | 1.133 | 1.134 | 0.996 | 0.886 |
| | n-decane | 0.848 | 0.937 | 0.988 | 0.996 | 1.012 | 1.023 | 1.026 | 1.028 | 1.019 | 1.051 | 0.937 | 0.859 |
| | 1-heptene | 0.886 | 0.985 | 1.037 | 1.071 | 1.123 | 1.150 | 1.176 | 1.177 | 1.126 | 1.139 | 0.977 | 0.895 |
| | hexane | 0.937 | 1.049 | 1.191 | 1.202 | 1.307 | 1.407 | 1.400 | 1.401 | 1.372 | 1.253 | 1.101 | 0.942 |
| | nonene | 0.842 | 0.931 | 0.976 | 0.984 | 0.999 | 1.011 | 1.014 | 1.016 | 1.007 | 1.039 | 0.928 | 0.853 |
| Alcohols | methanol | 0.952 | 1.065 | 1.209 | 1.243 | 1.356 | 1.436 | 1.428 | 1.429 | 1.408 | 1.308 | 1.119 | 0.958 |
| | ethanol | 0.908 | 1.010 | 1.088 | 1.126 | 1.203 | 1.257 | 1.255 | 1.256 | 1.238 | 1.194 | 1.020 | 0.916 |
| | isopropanol | 0.889 | 0.987 | 1.063 | 1.087 | 1.151 | 1.210 | 1.209 | 1.210 | 1.188 | 1.149 | 1.000 | 0.898 |
| | butanols (iso Butyl Alcohol) | 0.855 | 0.946 | 1.005 | 1.019 | 1.050 | 1.077 | 1.080 | 1.081 | 1.068 | 1.077 | 0.952 | 0.866 |
| | decanol | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| | hexanol | 0.849 | 0.940 | 0.990 | 0.998 | 1.014 | 1.025 | 1.028 | 1.030 | 1.021 | 1.053 | 0.941 | 0.860 |
| | 2-ethylhexanol | 0.846 | 0.934 | 0.980 | 0.989 | 1.004 | 1.016 | 1.020 | 1.022 | 1.013 | 1.044 | 0.932 | 0.857 |
| Benzene/Toluene | Benzene | 0.914 | 1.019 | 1.111 | 1.153 | 1.251 | 1.330 | 1.325 | 1.326 | 1.302 | 1.221 | 1.037 | 0.921 |
| | Toluene | 0.872 | 0.966 | 1.028 | 1.048 | 1.087 | 1.111 | 1.112 | 1.113 | 1.103 | 1.108 | 0.971 | 0.882 |
| Carboxylic Acids | acetic acid | 0.857 | 0.949 | 1.010 | 1.025 | 1.045 | 1.068 | 1.086 | 1.088 | 1.051 | 1.079 | 0.947 | 0.868 |
| | propionic acid | 0.851 | 0.940 | 0.986 | 0.994 | 1.010 | 1.038 | 1.044 | 1.045 | 1.026 | 1.049 | 0.937 | 0.861 |
| | butyric acid | 0.846 | 0.936 | 0.984 | 0.992 | 1.011 | 1.025 | 1.029 | 1.030 | 1.022 | 1.048 | 0.935 | 0.858 |
| Chemical Products NEC | Assume non-volatile | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| Chemical Additives | Assume non-volatile | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| Crude Petroleum | crude oil | 0.872 | 0.969 | 1.042 | 1.042 | 1.081 | 1.118 | 1.118 | 1.119 | 1.106 | 1.090 | 0.979 | 0.880 |
| | crude oil RVP 5 | 0.921 | 1.033 | 1.158 | 1.142 | 1.227 | 1.311 | 1.304 | 1.305 | 1.281 | 1.177 | 1.067 | 0.925 |
| Distillate Fuel Oils | #1 diesel | 0.848 | 0.937 | 0.984 | 0.993 | 1.010 | 1.023 | 1.027 | 1.028 | 1.019 | 1.049 | 0.935 | 0.859 |
| | #2 diesel | 0.846 | 0.934 | 0.980 | 0.989 | 1.004 | 1.016 | 1.020 | 1.021 | 1.012 | 1.044 | 0.932 | 0.857 |
| | marine diesel oil | 0.846 | 0.934 | 0.980 | 0.989 | 1.004 | 1.016 | 1.020 | 1.021 | 1.012 | 1.044 | 0.932 | 0.857 |
| | gas oil | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| Gasoline | Gasoline RVP 6 | 0.925 | 1.039 | 1.195 | 1.195 | 1.288 | 1.342 | 1.333 | 1.334 | 1.325 | 1.237 | 1.096 | 0.928 |
| | Gasoline RVP 7 | 0.928 | 1.045 | 1.232 | 1.248 | 1.350 | 1.372 | 1.362 | 1.363 | 1.368 | 1.298 | 1.125 | 0.931 |
| | Gasoline RVP 7.8 | 0.963 | 1.087 | 1.238 | 1.270 | 1.398 | 1.446 | 1.434 | 1.434 | 1.432 | 1.325 | 1.128 | 0.964 |
| | Gasoline RVP 8.3 | 0.969 | 1.095 | 1.251 | 1.284 | 1.418 | 1.468 | 1.454 | 1.455 | 1.453 | 1.339 | 1.138 | 0.969 |
| | Gasoline RVP 10 | 1.017 | 1.156 | 1.244 | 1.292 | 1.450 | 1.508 | 1.492 | 1.492 | 1.491 | 1.351 | 1.125 | 1.014 |
| | Gasoline RVP 11.5 | 1.002 | 1.142 | 1.333 | 1.369 | 1.541 | 1.597 | 1.577 | 1.577 | 1.581 | 1.421 | 1.196 | 0.998 |
| | Gasoline RVP 13 | 1.017 | 1.162 | 1.373 | 1.405 | 1.583 | 1.624 | 1.602 | 1.603 | 1.615 | 1.452 | 1.225 | 1.011 |
| Kerosene | kerosene (Fuel Oil #1) | 0.848 | 0.937 | 0.982 | 0.993 | 1.011 | 1.025 | 1.029 | 1.030 | 1.020 | 1.049 | 0.934 | 0.859 |
| | jet kerosene (Jet A) | 0.846 | 0.935 | 0.980 | 0.989 | 1.005 | 1.017 | 1.021 | 1.022 | 1.013 | 1.045 | 0.932 | 0.857 |
| | jet naphtha (JP-4) | 0.911 | 1.016 | 1.074 | 1.071 | 1.141 | 1.238 | 1.236 | 1.236 | 1.202 | 1.117 | 1.005 | 0.918 |
| Naphtha and Solvents | Naphtha | 0.845 | 0.934 | 0.980 | 0.988 | 1.004 | 1.014 | 1.018 | 1.019 | 1.011 | 1.042 | 0.931 | 0.856 |
| | Coker gas | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| | Cat Gas | 0.911 | 1.016 | 1.074 | 1.071 | 1.141 | 1.238 | 1.236 | 1.236 | 1.202 | 1.117 | 1.005 | 0.918 |
| | Alkylates | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |

| | | Values for P2 in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | 0 | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| Organic Compounds NEC | Assume non-volatile | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| Other Hydrocarbons | Styrene | 0.848 | 0.938 | 0.993 | 1.006 | 1.023 | 1.036 | 1.047 | 1.048 | 1.030 | 1.060 | 0.937 | 0.859 |
| | Cumene | 0.850 | 0.940 | 0.986 | 0.994 | 1.015 | 1.040 | 1.044 | 1.045 | 1.031 | 1.049 | 0.937 | 0.861 |
| | MEK | 0.903 | 1.006 | 1.075 | 1.188 | 1.299 | 1.296 | 1.292 | 1.293 | 1.301 | 1.292 | 1.006 | 0.911 |
| | MTBE | 1.035 | 1.173 | 1.106 | 1.463 | 1.736 | 1.624 | 1.607 | 1.608 | 1.675 | 1.679 | 1.015 | 1.034 |
| | Butyl Acrylate | 0.850 | 0.939 | 0.985 | 0.993 | 1.028 | 1.037 | 1.041 | 1.042 | 1.035 | 1.052 | 0.936 | 0.860 |
| | Vinyl Acetate | 0.915 | 1.021 | 1.148 | 1.187 | 1.316 | 1.459 | 1.451 | 1.452 | 1.406 | 1.254 | 1.068 | 0.922 |
| | Xylene | 0.849 | 0.938 | 1.001 | 1.008 | 1.025 | 1.052 | 1.065 | 1.066 | 1.038 | 1.062 | 0.943 | 0.859 |
| | Propyl Acetate | 0.869 | 0.963 | 1.054 | 1.057 | 1.080 | 1.123 | 1.143 | 1.144 | 1.094 | 1.108 | 0.987 | 0.879 |
| | MIBK | 0.850 | 0.940 | 0.989 | 1.012 | 1.029 | 1.049 | 1.062 | 1.063 | 1.036 | 1.066 | 0.937 | 0.861 |
| Petroleum Products NEC | Lube oil | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| | Light and Heavy Cycle Oils | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |
| Residual Fuel Oil | Residual Fuel | 0.846 | 0.934 | 0.980 | 0.989 | 1.004 | 1.016 | 1.020 | 1.022 | 1.013 | 1.045 | 0.932 | 0.857 |
| | Marine Residual Fuel | 0.847 | 0.936 | 0.985 | 0.996 | 1.015 | 1.029 | 1.032 | 1.034 | 1.024 | 1.053 | 0.936 | 0.858 |
| | No. 6 Fuel Oil | 0.845 | 0.934 | 0.979 | 0.988 | 1.003 | 1.014 | 1.018 | 1.019 | 1.011 | 1.043 | 0.931 | 0.856 |

**Some of these cargos may emit if placed in a 1 pound barge.**
**None of these cargos will emit if placed in a 3 pound barge.**
**No need to model emissions for any of these cargos that are shipped in 3 pound or 6 pound barges.**
**MODEL THIS ENTIRE SET FOR EMISSIONS WHEN SHIPPED IN A 1 POUND BARGE.**

| | | Values for P2 in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 1.022 | 1.210 | 1.406 | 1.542 | 1.696 | 1.762 | 1.749 | 1.646 | 1.499 | 1.416 | 1.158 | 1.005 |
| | n-decane | 0.984 | 1.162 | 1.311 | 1.417 | 1.515 | 1.561 | 1.537 | 1.462 | 1.353 | 1.303 | 1.086 | 0.969 |
| | 1-heptene | 1.033 | 1.217 | 1.377 | 1.542 | 1.692 | 1.798 | 1.797 | 1.690 | 1.499 | 1.426 | 1.136 | 1.017 |
| | hexane | 1.100 | 1.304 | 1.581 | 1.738 | 2.053 | 2.195 | 2.187 | 2.030 | 1.808 | 1.584 | 1.286 | 1.082 |
| | nonene | 0.977 | 1.154 | 1.295 | 1.399 | 1.496 | 1.543 | 1.519 | 1.444 | 1.337 | 1.287 | 1.075 | 0.962 |
| Alcohols | methanol | 1.118 | 1.325 | 1.605 | 1.805 | 2.117 | 2.256 | 2.262 | 2.096 | 1.855 | 1.655 | 1.307 | 1.099 |
| | ethanol | 1.060 | 1.252 | 1.444 | 1.624 | 1.851 | 1.966 | 1.970 | 1.839 | 1.637 | 1.498 | 1.187 | 1.043 |
| | isopropanol | 1.036 | 1.224 | 1.411 | 1.561 | 1.768 | 1.879 | 1.872 | 1.755 | 1.574 | 1.437 | 1.162 | 1.019 |
| | butanols (iso Butyl Alcohol) | 0.993 | 1.174 | 1.334 | 1.454 | 1.586 | 1.655 | 1.637 | 1.549 | 1.417 | 1.338 | 1.105 | 0.978 |
| | decanol | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| | hexanol | 0.985 | 1.166 | 1.314 | 1.420 | 1.518 | 1.565 | 1.541 | 1.464 | 1.356 | 1.305 | 1.090 | 0.970 |
| | 2-ethylhexanol | 0.981 | 1.159 | 1.301 | 1.406 | 1.503 | 1.552 | 1.528 | 1.454 | 1.345 | 1.294 | 1.080 | 0.966 |
| Benzene/Toluene | Benzene | 1.069 | 1.262 | 1.475 | 1.668 | 1.946 | 2.053 | 2.028 | 1.896 | 1.719 | 1.538 | 1.208 | 1.052 |
| | Toluene | 1.014 | 1.198 | 1.364 | 1.499 | 1.645 | 1.708 | 1.690 | 1.595 | 1.461 | 1.381 | 1.128 | 0.998 |

| | | Values for P2 in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Carboxylic Acids | acetic acid | 0.996 | 1.175 | 1.344 | 1.461 | 1.567 | 1.655 | 1.646 | 1.557 | 1.401 | 1.341 | 1.102 | 0.980 |
| | propionic acid | 0.987 | 1.166 | 1.309 | 1.414 | 1.524 | 1.587 | 1.565 | 1.486 | 1.365 | 1.301 | 1.086 | 0.972 |
| | butyric acid | 0.981 | 1.161 | 1.306 | 1.411 | 1.516 | 1.565 | 1.541 | 1.465 | 1.357 | 1.298 | 1.083 | 0.967 |
| Chemical Products NEC | Assume non-volatile | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| Chemical Additives | Assume non-volatile | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| Crude Petroleum | crude oil | 1.017 | 1.200 | 1.382 | 1.489 | 1.648 | 1.720 | 1.700 | 1.601 | 1.463 | 1.361 | 1.138 | 1.000 |
| | crude oil RVP 5 | 1.084 | 1.279 | 1.535 | 1.646 | 1.920 | 2.038 | 2.025 | 1.881 | 1.686 | 1.489 | 1.246 | 1.065 |
| Distillate Fuel Oils | #1 diesel | 0.983 | 1.162 | 1.306 | 1.412 | 1.513 | 1.564 | 1.542 | 1.465 | 1.353 | 1.299 | 1.084 | 0.968 |
| | #2 diesel | 0.981 | 1.159 | 1.301 | 1.406 | 1.503 | 1.552 | 1.528 | 1.453 | 1.345 | 1.294 | 1.080 | 0.966 |
| | marine diesel oil | 0.981 | 1.159 | 1.301 | 1.406 | 1.503 | 1.552 | 1.528 | 1.453 | 1.345 | 1.294 | 1.080 | 0.966 |
| | gas oil | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| Gasoline | Gasoline RVP 6 | 1.090 | 1.290 | 1.584 | 1.732 | 2.004 | 2.096 | 2.092 | 1.937 | 1.737 | 1.571 | 1.282 | 1.071 |
| | Gasoline RVP 7 | 1.096 | 1.301 | 1.633 | 1.818 | 2.088 | 2.155 | 2.160 | 1.993 | 1.787 | 1.654 | 1.318 | 1.077 |
| | Gasoline RVP 7.8 | 1.140 | 1.343 | 1.641 | 1.856 | 2.182 | 2.267 | 2.265 | 2.088 | 1.871 | 1.693 | 1.322 | 1.120 |
| Gasoline | Gasoline RVP 8.3 | 1.149 | 1.352 | 1.658 | 1.879 | 2.217 | 2.303 | 2.302 | 2.119 | 1.897 | 1.714 | 1.335 | 1.128 |
| | Gasoline RVP 10 | 1.213 | 1.409 | 1.647 | 1.899 | 2.278 | 2.389 | 2.410 | 2.205 | 1.942 | 1.736 | 1.321 | 1.190 |
| | Gasoline RVP 11.5 | 1.197 | 1.406 | 1.765 | 2.018 | 2.429 | 2.517 | 2.522 | 2.305 | 2.054 | 1.834 | 1.408 | 1.175 |
| | Gasoline RVP 13 | 1.218 | 1.430 | 1.818 | 2.075 | 2.494 | 2.574 | 2.591 | 2.359 | 2.092 | 1.881 | 1.444 | 1.195 |
| Kerosene | kerosene (Fuel Oil #1) | 0.983 | 1.161 | 1.304 | 1.412 | 1.515 | 1.567 | 1.544 | 1.467 | 1.355 | 1.300 | 1.082 | 0.968 |
| | jet kerosene (Jet A) | 0.981 | 1.159 | 1.301 | 1.407 | 1.505 | 1.554 | 1.530 | 1.455 | 1.346 | 1.294 | 1.080 | 0.966 |
| | jet naphtha (JP-4) | 1.066 | 1.253 | 1.426 | 1.534 | 1.780 | 1.862 | 1.791 | 1.697 | 1.593 | 1.399 | 1.170 | 1.049 |
| Naphtha and Solvents | Naphtha | 0.981 | 1.158 | 1.301 | 1.405 | 1.503 | 1.549 | 1.525 | 1.449 | 1.342 | 1.292 | 1.079 | 0.966 |
| | Coker gas | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| | Cat Gas | 1.066 | 1.253 | 1.426 | 1.534 | 1.780 | 1.862 | 1.791 | 1.697 | 1.593 | 1.399 | 1.170 | 1.049 |
| | Alkylates | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| | 0 | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| Organic Compounds NEC | Assume non-volatile | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| Other Hydrocarbons | Styrene | 0.984 | 1.162 | 1.321 | 1.432 | 1.533 | 1.595 | 1.578 | 1.497 | 1.367 | 1.316 | 1.089 | 0.969 |
| | Cumene | 0.986 | 1.165 | 1.308 | 1.414 | 1.529 | 1.589 | 1.565 | 1.486 | 1.371 | 1.300 | 1.086 | 0.971 |
| | MEK | 1.056 | 1.244 | 1.426 | 1.738 | 1.976 | 2.008 | 1.992 | 1.861 | 1.708 | 1.632 | 1.171 | 1.039 |
| | MTBE | 1.231 | 1.407 | 1.465 | 2.224 | 2.634 | 2.512 | 2.470 | 2.282 | 2.166 | 2.165 | 1.187 | 1.208 |
| | Butyl Acrylate | 0.986 | 1.164 | 1.308 | 1.419 | 1.540 | 1.585 | 1.560 | 1.482 | 1.373 | 1.308 | 1.085 | 0.971 |
| | Vinyl Acetate | 1.072 | 1.271 | 1.524 | 1.719 | 2.087 | 2.260 | 2.234 | 2.082 | 1.860 | 1.582 | 1.245 | 1.054 |
| | Xylene | 0.984 | 1.163 | 1.329 | 1.435 | 1.546 | 1.613 | 1.598 | 1.516 | 1.383 | 1.318 | 1.095 | 0.969 |
| | Propyl Acetate | 1.011 | 1.192 | 1.400 | 1.509 | 1.643 | 1.735 | 1.728 | 1.631 | 1.463 | 1.382 | 1.148 | 0.995 |
| | MIBK | 0.987 | 1.165 | 1.318 | 1.441 | 1.543 | 1.616 | 1.602 | 1.518 | 1.380 | 1.323 | 1.086 | 0.971 |
| Petroleum Products NEC | Lube oil | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.525 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| | Light and Heavy Cycle Oils | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.525 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |
| Residual Fuel Oil | Residual Fuel | 0.980 | 1.158 | 1.301 | 1.406 | 1.504 | 1.552 | 1.529 | 1.454 | 1.345 | 1.294 | 1.080 | 0.966 |
| | Marine Residual Fuel | 0.982 | 1.161 | 1.308 | 1.417 | 1.521 | 1.574 | 1.552 | 1.474 | 1.360 | 1.305 | 1.086 | 0.967 |

| | | Values for P2 in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | No. 6 Fuel Oil | 0.980 | 1.158 | 1.300 | 1.404 | 1.500 | 1.548 | 1.524 | 1.450 | 1.342 | 1.292 | 1.079 | 0.965 |

**Some of these cargos may emit if placed in a 1 pound barge.**
**None of these cargos will emit if placed in a 3 pound barge.**
**No need to model emissions for any of these cargos that are shipped in 3 pound or 6 pound barges.**
**MODEL THIS ENTIRE SET FOR EMISSIONS WHEN SHIPPED IN A 1 POUND BARGE.**

## *Galveston*

**Galveston Area**
**Evaporation Loss from Low Pressure Tanks**
This formula determines the gauge pressure at which no emissions will occur, given variable inputs for ambient temperature, solar insolation, trip duration, and product vapor pressure.
This formula is based on API Bulletin 2516 - "Evaporation Loss From Low-Pressure Storage Tanks"
**Reference:**
American Petroleum Institute, 2006. API Bulletin 2516 - "Evaporation Loss From Low-Pressure Storage Tanks". March 1962, Reaffirmed February 2006.

P2 = (t2/t1) x (Pa + P1 - p1 ) - (Pa - p2)
where:
P2 = gauge pressure at which the pressure vent opens
Pa = atmospheric pressure at sea level = 14.7
P1 = gauge pressure at which the vacuum vent opens
p1 = true vapor pressure at min. surface temp. (deg. F), in psia
p2 = true vapor pressure at max. surface temp. (deg. F), in psia
t1 = minimum avg. vapor space temperature (degrees R)
t2 = maximum avg. vapor space temperature (degrees R)

| | | | |
|---|---|---|---|
| P2 | | | |
| Pa | 14.7 | 14.7 | 14.7 |
| P1 | 0.0625 | 0.0625 | 0.0625 |
| p1 | varies | varies | varies |
| p2 | varies | varies | varies |
| t1 | varies | varies | varies |
| t2 | varies | varies | varies |

**Assumptions:**
temperature for p1 and t1 = average ambient air temp

| | | Values for P2 in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.209 | 0.229 | 0.244 | 0.249 | 0.277 | 0.260 | 0.257 | 0.257 | 0.255 | 0.250 | 0.227 | 0.195 |
| | n-decane | 0.201 | 0.222 | 0.233 | 0.236 | 0.244 | 0.246 | 0.244 | 0.244 | 0.241 | 0.238 | 0.216 | 0.200 |
| | 1-heptene | 0.212 | 0.232 | 0.240 | 0.238 | 0.281 | 0.258 | 0.255 | 0.254 | 0.253 | 0.252 | 0.224 | 0.195 |
| | hexane | 0.227 | 0.245 | 0.263 | 0.268 | 0.331 | 0.291 | 0.286 | 0.286 | 0.287 | 0.267 | 0.248 | 0.183 |
| | nonene | 0.200 | 0.221 | 0.231 | 0.234 | 0.241 | 0.244 | 0.242 | 0.242 | 0.239 | 0.236 | 0.214 | 0.199 |
| Alcohols | methanol | 0.230 | 0.248 | 0.267 | 0.278 | 0.344 | 0.296 | 0.292 | 0.292 | 0.293 | 0.276 | 0.251 | 0.188 |
| | ethanol | 0.217 | 0.237 | 0.248 | 0.259 | 0.298 | 0.276 | 0.272 | 0.272 | 0.271 | 0.260 | 0.232 | 0.195 |
| | isopropanol | 0.212 | 0.232 | 0.244 | 0.252 | 0.282 | 0.270 | 0.267 | 0.266 | 0.265 | 0.253 | 0.228 | 0.196 |
| | butanols (iso Butyl Alcohol) | 0.203 | 0.224 | 0.235 | 0.240 | 0.254 | 0.253 | 0.251 | 0.250 | 0.248 | 0.242 | 0.218 | 0.199 |
| | decanol | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| | hexanol | 0.201 | 0.223 | 0.233 | 0.236 | 0.245 | 0.247 | 0.244 | 0.244 | 0.241 | 0.238 | 0.216 | 0.200 |
| | 2-ethylhexanol | 0.200 | 0.222 | 0.232 | 0.235 | 0.242 | 0.246 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| Benzene/Toluene | Benzene | 0.220 | 0.239 | 0.251 | 0.263 | 0.312 | 0.283 | 0.279 | 0.279 | 0.279 | 0.263 | 0.235 | 0.190 |
| | Toluene | 0.208 | 0.228 | 0.239 | 0.245 | 0.266 | 0.257 | 0.254 | 0.254 | 0.252 | 0.247 | 0.222 | 0.197 |
| Carboxylic Acids | acetic acid | 0.204 | 0.224 | 0.241 | 0.240 | 0.255 | 0.250 | 0.247 | 0.247 | 0.245 | 0.242 | 0.221 | 0.199 |
| | propionic acid | 0.202 | 0.223 | 0.232 | 0.236 | 0.244 | 0.249 | 0.246 | 0.246 | 0.241 | 0.238 | 0.216 | 0.200 |
| | butyric acid | 0.201 | 0.222 | 0.232 | 0.235 | 0.243 | 0.247 | 0.244 | 0.244 | 0.241 | 0.238 | 0.215 | 0.200 |
| Chemical Products NEC | Assume non-volatile | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| Chemical Additives | Assume non-volatile | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| Crude Petroleum | crude oil | 0.210 | 0.229 | 0.240 | 0.242 | 0.267 | 0.255 | 0.252 | 0.252 | 0.251 | 0.243 | 0.224 | 0.191 |
| | crude oil RVP 5 | 0.227 | 0.242 | 0.257 | 0.255 | 0.316 | 0.274 | 0.270 | 0.270 | 0.271 | 0.254 | 0.242 | 0.175 |
| Distillate Fuel Oils | #1 diesel | 0.201 | 0.222 | 0.232 | 0.236 | 0.243 | 0.247 | 0.244 | 0.244 | 0.241 | 0.238 | 0.215 | 0.200 |
| | #2 diesel | 0.200 | 0.222 | 0.232 | 0.235 | 0.242 | 0.246 | 0.243 | 0.243 | 0.240 | 0.237 | 0.215 | 0.200 |
| | marine diesel oil | 0.200 | 0.222 | 0.232 | 0.235 | 0.242 | 0.246 | 0.243 | 0.243 | 0.240 | 0.237 | 0.215 | 0.200 |
| | gas oil | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| Gasoline | Gasoline RVP 6 | 0.229 | 0.244 | 0.262 | 0.265 | 0.339 | 0.276 | 0.272 | 0.272 | 0.274 | 0.263 | 0.248 | 0.172 |
| | Gasoline RVP 7 | 0.230 | 0.245 | 0.268 | 0.275 | 0.363 | 0.279 | 0.274 | 0.274 | 0.276 | 0.272 | 0.254 | 0.169 |
| | Gasoline RVP 7.8 | 0.240 | 0.253 | 0.268 | 0.279 | 0.376 | 0.287 | 0.283 | 0.282 | 0.285 | 0.276 | 0.255 | 0.165 |
| | Gasoline RVP 8.3 | 0.242 | 0.255 | 0.270 | 0.281 | 0.384 | 0.289 | 0.284 | 0.284 | 0.287 | 0.277 | 0.257 | 0.162 |
| | Gasoline RVP 10 | 0.256 | 0.268 | 0.267 | 0.282 | 0.398 | 0.290 | 0.286 | 0.286 | 0.289 | 0.278 | 0.256 | 0.154 |
| | Gasoline RVP 11.5 | 0.256 | 0.265 | 0.281 | 0.293 | 0.430 | 0.298 | 0.293 | 0.293 | 0.298 | 0.288 | 0.270 | 0.146 |
| | Gasoline RVP 13 | 0.262 | 0.270 | 0.286 | 0.298 | 0.449 | 0.298 | 0.293 | 0.293 | 0.299 | 0.291 | 0.276 | 0.138 |
| Kerosene | kerosene (Fuel Oil #1) | 0.201 | 0.222 | 0.232 | 0.236 | 0.244 | 0.247 | 0.244 | 0.244 | 0.241 | 0.238 | 0.215 | 0.200 |
| | jet kerosene (Jet A) | 0.201 | 0.222 | 0.232 | 0.235 | 0.242 | 0.246 | 0.243 | 0.243 | 0.240 | 0.237 | 0.215 | 0.200 |
| | jet naphtha (JP-4) | 0.220 | 0.238 | 0.245 | 0.246 | 0.280 | 0.271 | 0.267 | 0.267 | 0.267 | 0.247 | 0.229 | 0.189 |
| Naphtha and Solvents | Naphtha | 0.201 | 0.222 | 0.231 | 0.234 | 0.243 | 0.245 | 0.242 | 0.242 | 0.239 | 0.237 | 0.214 | 0.198 |
| | Coker gas | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| | Cat Gas | 0.220 | 0.238 | 0.245 | 0.246 | 0.280 | 0.271 | 0.267 | 0.267 | 0.267 | 0.247 | 0.229 | 0.189 |
| | Alkylates | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| | 0 | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |

| | | Values for P2 in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Organic Compounds NEC | Assume non-volatile | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| Other Hydrocarbons | Styrene | 0.201 | 0.222 | 0.235 | 0.237 | 0.248 | 0.248 | 0.245 | 0.245 | 0.242 | 0.240 | 0.218 | 0.199 |
| | Cumene | 0.202 | 0.223 | 0.232 | 0.236 | 0.244 | 0.249 | 0.246 | 0.246 | 0.243 | 0.238 | 0.215 | 0.200 |
| | MEK | 0.218 | 0.236 | 0.245 | 0.275 | 0.335 | 0.278 | 0.275 | 0.274 | 0.274 | 0.275 | 0.230 | 0.189 |
| | MTBE | 0.257 | 0.270 | 0.247 | 0.338 | 0.489 | 0.310 | 0.305 | 0.305 | 0.309 | 0.332 | 0.234 | 0.164 |
| | Butyl Acrylate | 0.202 | 0.222 | 0.232 | 0.235 | 0.249 | 0.248 | 0.246 | 0.245 | 0.243 | 0.239 | 0.215 | 0.200 |
| | Vinyl Acetate | 0.221 | 0.239 | 0.257 | 0.269 | 0.325 | 0.300 | 0.296 | 0.296 | 0.297 | 0.268 | 0.241 | 0.189 |
| | Xylene | 0.201 | 0.222 | 0.235 | 0.238 | 0.249 | 0.246 | 0.249 | 0.249 | 0.242 | 0.240 | 0.218 | 0.199 |
| | Propyl Acetate | 0.207 | 0.227 | 0.243 | 0.245 | 0.267 | 0.253 | 0.260 | 0.259 | 0.248 | 0.247 | 0.226 | 0.197 |
| | MIBK | 0.202 | 0.223 | 0.232 | 0.238 | 0.250 | 0.248 | 0.246 | 0.246 | 0.243 | 0.240 | 0.215 | 0.199 |
| Petroleum Products NEC | Lube oil | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| | Light and Heavy Cycle Oils | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |
| Residual Fuel Oil | Residual Fuel | 0.200 | 0.221 | 0.232 | 0.235 | 0.242 | 0.246 | 0.243 | 0.243 | 0.240 | 0.237 | 0.215 | 0.200 |
| | Marine Residual Fuel | 0.201 | 0.222 | 0.232 | 0.236 | 0.245 | 0.247 | 0.245 | 0.244 | 0.242 | 0.238 | 0.215 | 0.200 |
| | No. 6 Fuel Oil | 0.200 | 0.221 | 0.231 | 0.235 | 0.241 | 0.245 | 0.243 | 0.243 | 0.240 | 0.237 | 0.214 | 0.200 |

**None of these cargos will emit on this 2 hour trip when loaded in a 1 pound barge.**
**No need to model emissions for any of these cargos on this trip length.**

| | | Values for P2 in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.717 | 0.819 | 0.888 | 0.938 | 0.994 | 1.019 | 1.012 | 1.012 | 0.970 | 0.943 | 0.813 | 0.726 |
| | n-decane | 0.686 | 0.780 | 0.830 | 0.846 | 0.877 | 0.894 | 0.883 | 0.882 | 0.868 | 0.855 | 0.753 | 0.685 |
| | 1-heptene | 0.726 | 0.815 | 0.870 | 0.944 | 0.995 | 1.042 | 1.054 | 1.053 | 0.970 | 0.954 | 0.796 | 0.723 |
| | hexane | 0.783 | 0.888 | 0.994 | 1.081 | 1.217 | 1.302 | 1.297 | 1.296 | 1.202 | 1.076 | 0.926 | 0.804 |
| | nonene | 0.681 | 0.775 | 0.820 | 0.835 | 0.866 | 0.884 | 0.872 | 0.871 | 0.858 | 0.845 | 0.744 | 0.680 |
| Alcohols | methanol | 0.794 | 0.903 | 1.009 | 1.129 | 1.257 | 1.326 | 1.329 | 1.328 | 1.226 | 1.124 | 0.938 | 0.815 |
| | ethanol | 0.746 | 0.842 | 0.911 | 1.000 | 1.087 | 1.137 | 1.139 | 1.138 | 1.071 | 1.003 | 0.837 | 0.751 |
| | isopropanol | 0.727 | 0.825 | 0.891 | 0.952 | 1.033 | 1.087 | 1.084 | 1.083 | 1.030 | 0.957 | 0.816 | 0.733 |
| | butanols (iso Butyl Alcohol) | 0.693 | 0.791 | 0.843 | 0.874 | 0.920 | 0.951 | 0.942 | 0.941 | 0.915 | 0.882 | 0.767 | 0.696 |
| | decanol | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| | hexanol | 0.687 | 0.785 | 0.831 | 0.848 | 0.879 | 0.897 | 0.885 | 0.884 | 0.870 | 0.858 | 0.755 | 0.690 |
| | 2-ethylhexanol | 0.683 | 0.778 | 0.823 | 0.839 | 0.869 | 0.888 | 0.876 | 0.876 | 0.863 | 0.849 | 0.747 | 0.682 |
| Benzene/Toluene | Benzene | 0.756 | 0.852 | 0.930 | 1.036 | 1.147 | 1.215 | 1.202 | 1.202 | 1.134 | 1.036 | 0.858 | 0.763 |
| | Toluene | 0.710 | 0.806 | 0.862 | 0.908 | 0.959 | 0.986 | 0.977 | 0.976 | 0.945 | 0.915 | 0.787 | 0.712 |
| Carboxylic Acids | acetic acid | 0.696 | 0.789 | 0.859 | 0.876 | 0.912 | 0.950 | 0.953 | 0.952 | 0.902 | 0.885 | 0.780 | 0.694 |
| | propionic acid | 0.688 | 0.782 | 0.828 | 0.844 | 0.878 | 0.912 | 0.900 | 0.900 | 0.881 | 0.854 | 0.752 | 0.687 |
| | butyric acid | 0.684 | 0.779 | 0.827 | 0.842 | 0.877 | 0.897 | 0.885 | 0.884 | 0.870 | 0.854 | 0.750 | 0.684 |
| Chemical Products NEC | Assume non-volatile | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| Chemical Additives | Assume non-volatile | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| Crude Petroleum | crude oil | 0.715 | 0.809 | 0.873 | 0.901 | 0.964 | 1.001 | 0.991 | 0.990 | 0.952 | 0.906 | 0.801 | 0.719 |
| | crude oil RVP 5 | 0.776 | 0.867 | 0.966 | 1.019 | 1.142 | 1.214 | 1.207 | 1.206 | 1.120 | 1.014 | 0.902 | 0.789 |
| Distillate Fuel Oils | #1 diesel | 0.685 | 0.780 | 0.826 | 0.843 | 0.875 | 0.895 | 0.884 | 0.883 | 0.869 | 0.853 | 0.750 | 0.685 |
| | #2 diesel | 0.683 | 0.778 | 0.823 | 0.839 | 0.869 | 0.888 | 0.876 | 0.876 | 0.863 | 0.849 | 0.747 | 0.683 |
| | marine diesel oil | 0.683 | 0.778 | 0.823 | 0.839 | 0.869 | 0.888 | 0.876 | 0.876 | 0.863 | 0.849 | 0.747 | 0.683 |
| | gas oil | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| Gasoline | Gasoline RVP 6 | 0.782 | 0.880 | 0.996 | 1.085 | 1.203 | 1.249 | 1.246 | 1.246 | 1.147 | 1.077 | 0.934 | 0.804 |
| | Gasoline RVP 7 | 0.788 | 0.894 | 1.026 | 1.152 | 1.263 | 1.285 | 1.286 | 1.286 | 1.174 | 1.140 | 0.965 | 0.820 |
| | Gasoline RVP 7.8 | 0.824 | 0.911 | 1.031 | 1.186 | 1.322 | 1.363 | 1.361 | 1.361 | 1.238 | 1.172 | 0.972 | 0.840 |
| Gasoline | Gasoline RVP 8.3 | 0.832 | 0.918 | 1.041 | 1.205 | 1.346 | 1.387 | 1.386 | 1.386 | 1.257 | 1.189 | 0.984 | 0.848 |
| | Gasoline RVP 10 | 0.885 | 0.935 | 1.034 | 1.232 | 1.390 | 1.437 | 1.446 | 1.446 | 1.293 | 1.212 | 0.982 | 0.872 |
| | Gasoline RVP 11.5 | 0.878 | 0.957 | 1.107 | 1.317 | 1.493 | 1.537 | 1.538 | 1.537 | 1.371 | 1.291 | 1.058 | 0.899 |
| | Gasoline RVP 13 | 0.898 | 0.975 | 1.138 | 1.362 | 1.542 | 1.574 | 1.580 | 1.580 | 1.396 | 1.332 | 1.094 | 0.922 |
| Kerosene | kerosene (Fuel Oil #1) | 0.685 | 0.780 | 0.825 | 0.844 | 0.876 | 0.897 | 0.886 | 0.885 | 0.871 | 0.854 | 0.749 | 0.684 |
| | jet kerosene (Jet A) | 0.684 | 0.778 | 0.823 | 0.839 | 0.870 | 0.889 | 0.877 | 0.877 | 0.864 | 0.849 | 0.747 | 0.683 |
| | jet naphtha (JP-4) | 0.754 | 0.838 | 0.899 | 0.933 | 1.040 | 1.124 | 1.089 | 1.088 | 1.056 | 0.936 | 0.829 | 0.750 |
| Naphtha and Solvents | Naphtha | 0.684 | 0.777 | 0.823 | 0.839 | 0.870 | 0.888 | 0.876 | 0.875 | 0.862 | 0.849 | 0.747 | 0.683 |
| | Coker gas | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| | Cat Gas | 0.754 | 0.838 | 0.899 | 0.933 | 1.040 | 1.124 | 1.089 | 1.088 | 1.056 | 0.936 | 0.829 | 0.750 |
| | Alkylates | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |

| | | Values for P2 in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | 0 | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| Organic Compounds NEC | Assume non-volatile | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| Other Hydrocarbons | Styrene | 0.686 | 0.780 | 0.839 | 0.856 | 0.889 | 0.913 | 0.908 | 0.907 | 0.877 | 0.865 | 0.762 | 0.685 |
| | Cumene | 0.688 | 0.782 | 0.828 | 0.844 | 0.884 | 0.913 | 0.900 | 0.900 | 0.884 | 0.854 | 0.752 | 0.687 |
| | MEK | 0.747 | 0.834 | 0.900 | 1.107 | 1.179 | 1.183 | 1.174 | 1.174 | 1.105 | 1.104 | 0.829 | 0.746 |
| | MTBE | 0.893 | 0.900 | 0.923 | 1.539 | 1.631 | 1.544 | 1.521 | 1.521 | 1.392 | 1.512 | 0.866 | 0.829 |
| | Butyl Acrylate | 0.687 | 0.781 | 0.827 | 0.847 | 0.893 | 0.910 | 0.898 | 0.897 | 0.881 | 0.868 | 0.751 | 0.686 |
| | Vinyl Acetate | 0.759 | 0.865 | 0.959 | 1.072 | 1.227 | 1.346 | 1.332 | 1.332 | 1.245 | 1.069 | 0.889 | 0.777 |
| | Xylene | 0.687 | 0.781 | 0.840 | 0.858 | 0.890 | 0.929 | 0.922 | 0.921 | 0.893 | 0.867 | 0.764 | 0.685 |
| | Propyl Acetate | 0.708 | 0.807 | 0.884 | 0.910 | 0.950 | 1.009 | 1.015 | 1.014 | 0.951 | 0.916 | 0.809 | 0.714 |
| | MIBK | 0.688 | 0.782 | 0.835 | 0.862 | 0.895 | 0.926 | 0.924 | 0.923 | 0.887 | 0.871 | 0.761 | 0.687 |
| Petroleum Products NEC | Lube oil | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| | Light and Heavy Cycle Oils | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |
| Residual Fuel Oil | Residual Fuel | 0.683 | 0.778 | 0.823 | 0.839 | 0.869 | 0.888 | 0.876 | 0.876 | 0.863 | 0.849 | 0.747 | 0.682 |
| | Marine Residual Fuel | 0.684 | 0.780 | 0.827 | 0.847 | 0.880 | 0.901 | 0.890 | 0.889 | 0.874 | 0.857 | 0.751 | 0.685 |
| | No. 6 Fuel Oil | 0.683 | 0.778 | 0.822 | 0.837 | 0.867 | 0.886 | 0.874 | 0.873 | 0.861 | 0.848 | 0.746 | 0.682 |

**Some of these cargos may emit if placed in a 1 pound barge.**
**None of these cargos will emit if placed in a 3 pound barge.**
**No need to model emissions for any of these cargos that are shipped in 3 pound or 6 pound barges.**
**MODEL THIS ENTIRE SET FOR EMISSIONS WHEN SHIPPED IN A 1 POUND BARGE.**

| | | Values for P2 in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.834 | 1.035 | 1.185 | 1.339 | 1.503 | 1.580 | 1.550 | 1.454 | 1.312 | 1.158 | 0.948 | 0.808 |
| | n-decane | 0.793 | 0.967 | 1.099 | 1.198 | 1.308 | 1.361 | 1.317 | 1.250 | 1.152 | 1.056 | 0.871 | 0.769 |
| | 1-heptene | 0.846 | 1.025 | 1.152 | 1.350 | 1.509 | 1.623 | 1.603 | 1.504 | 1.344 | 1.167 | 0.919 | 0.805 |
| | hexane | 0.921 | 1.162 | 1.340 | 1.558 | 1.903 | 2.044 | 2.022 | 1.873 | 1.677 | 1.324 | 1.087 | 0.879 |
| | nonene | 0.788 | 0.959 | 1.085 | 1.183 | 1.291 | 1.344 | 1.301 | 1.235 | 1.138 | 1.043 | 0.860 | 0.764 |
| Alcohols | methanol | 0.933 | 1.178 | 1.366 | 1.629 | 1.956 | 2.106 | 2.098 | 1.939 | 1.710 | 1.378 | 1.107 | 0.893 |
| | ethanol | 0.871 | 1.070 | 1.224 | 1.433 | 1.668 | 1.796 | 1.783 | 1.660 | 1.466 | 1.235 | 0.982 | 0.832 |
| | isopropanol | 0.847 | 1.043 | 1.191 | 1.360 | 1.582 | 1.700 | 1.676 | 1.567 | 1.401 | 1.182 | 0.953 | 0.815 |
| | butanols (iso Butyl Alcohol) | 0.803 | 0.985 | 1.120 | 1.241 | 1.386 | 1.461 | 1.424 | 1.344 | 1.224 | 1.090 | 0.890 | 0.780 |
| | decanol | 0.790 | 0.962 | 1.088 | 1.186 | 1.294 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| | hexanol | 0.796 | 0.973 | 1.101 | 1.202 | 1.312 | 1.365 | 1.320 | 1.254 | 1.155 | 1.058 | 0.873 | 0.774 |
| | 2-ethylhexanol | 0.790 | 0.963 | 1.090 | 1.188 | 1.297 | 1.352 | 1.308 | 1.242 | 1.144 | 1.048 | 0.863 | 0.767 |
| Benzene/Toluene | Benzene | 0.885 | 1.092 | 1.253 | 1.489 | 1.777 | 1.878 | 1.838 | 1.714 | 1.566 | 1.276 | 1.010 | 0.842 |
| | Toluene | 0.825 | 1.010 | 1.149 | 1.293 | 1.447 | 1.518 | 1.481 | 1.395 | 1.271 | 1.127 | 0.916 | 0.795 |
| Carboxylic Acids | acetic acid | 0.806 | 0.976 | 1.138 | 1.245 | 1.371 | 1.466 | 1.438 | 1.357 | 1.225 | 1.089 | 0.903 | 0.778 |
| | propionic acid | 0.797 | 0.970 | 1.097 | 1.197 | 1.321 | 1.390 | 1.345 | 1.276 | 1.173 | 1.054 | 0.870 | 0.772 |
| | butyric acid | 0.792 | 0.965 | 1.094 | 1.194 | 1.310 | 1.365 | 1.321 | 1.254 | 1.155 | 1.055 | 0.867 | 0.768 |
| Chemical Products NEC | Assume non-volatile | 0.790 | 0.962 | 1.088 | 1.186 | 1.293 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| Chemical Additives | Assume non-volatile | 0.790 | 0.962 | 1.088 | 1.186 | 1.293 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| Crude Petroleum | crude oil | 0.833 | 1.023 | 1.162 | 1.285 | 1.464 | 1.540 | 1.503 | 1.412 | 1.289 | 1.116 | 0.930 | 0.799 |
| | crude oil RVP 5 | 0.914 | 1.137 | 1.297 | 1.467 | 1.780 | 1.896 | 1.871 | 1.734 | 1.563 | 1.244 | 1.054 | 0.858 |
| Distillate Fuel Oils | #1 diesel | 0.793 | 0.966 | 1.094 | 1.195 | 1.307 | 1.365 | 1.323 | 1.255 | 1.153 | 1.053 | 0.867 | 0.769 |
| | #2 diesel | 0.790 | 0.963 | 1.090 | 1.188 | 1.297 | 1.352 | 1.308 | 1.242 | 1.143 | 1.048 | 0.863 | 0.767 |
| | marine diesel oil | 0.790 | 0.963 | 1.090 | 1.188 | 1.297 | 1.352 | 1.308 | 1.242 | 1.143 | 1.048 | 0.863 | 0.767 |
| | gas oil | 0.790 | 0.962 | 1.088 | 1.186 | 1.293 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| Gasoline | Gasoline RVP 6 | 0.923 | 1.167 | 1.345 | 1.568 | 1.865 | 1.967 | 1.952 | 1.803 | 1.608 | 1.310 | 1.098 | 0.872 |
| | Gasoline RVP 7 | 0.932 | 1.196 | 1.393 | 1.669 | 1.950 | 2.038 | 2.033 | 1.872 | 1.654 | 1.376 | 1.141 | 0.886 |
| | Gasoline RVP 7.8 | 0.978 | 1.219 | 1.405 | 1.722 | 2.057 | 2.154 | 2.144 | 1.973 | 1.754 | 1.417 | 1.154 | 0.903 |
| | Gasoline RVP 8.3 | 0.988 | 1.233 | 1.422 | 1.750 | 2.098 | 2.196 | 2.188 | 2.010 | 1.786 | 1.436 | 1.170 | 0.910 |
| | Gasoline RVP 10 | 1.058 | 1.257 | 1.419 | 1.794 | 2.176 | 2.309 | 2.324 | 2.124 | 1.850 | 1.461 | 1.173 | 0.928 |
| | Gasoline RVP 11.5 | 1.052 | 1.317 | 1.522 | 1.924 | 2.345 | 2.447 | 2.449 | 2.236 | 1.977 | 1.549 | 1.266 | 0.950 |
| | Gasoline RVP 13 | 1.079 | 1.356 | 1.570 | 1.994 | 2.421 | 2.524 | 2.541 | 2.312 | 2.025 | 1.591 | 1.311 | 0.969 |
| Kerosene | kerosene (Fuel Oil #1) | 0.793 | 0.965 | 1.093 | 1.195 | 1.310 | 1.368 | 1.325 | 1.257 | 1.155 | 1.054 | 0.866 | 0.769 |
| | jet kerosene (Jet A) | 0.791 | 0.963 | 1.090 | 1.189 | 1.298 | 1.353 | 1.310 | 1.244 | 1.145 | 1.049 | 0.863 | 0.767 |
| | jet naphtha (JP-4) | 0.883 | 1.066 | 1.200 | 1.334 | 1.615 | 1.664 | 1.577 | 1.491 | 1.448 | 1.162 | 0.964 | 0.828 |
| Naphtha and Solvents | Naphtha | 0.792 | 0.964 | 1.090 | 1.189 | 1.299 | 1.351 | 1.307 | 1.241 | 1.143 | 1.047 | 0.864 | 0.767 |
| | Coker gas | 0.790 | 0.962 | 1.088 | 1.186 | 1.293 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| | Cat Gas | 0.883 | 1.066 | 1.200 | 1.334 | 1.615 | 1.664 | 1.577 | 1.491 | 1.448 | 1.162 | 0.964 | 0.828 |
| | Alkylates | 0.790 | 0.962 | 1.088 | 1.186 | 1.293 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |

| | | Values for P2 in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | 0 | 0.790 | 0.962 | 1.088 | 1.186 | 1.293 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| Organic Compounds NEC | Assume non-volatile | 0.790 | 0.962 | 1.088 | 1.186 | 1.293 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.790 | 0.962 | 1.088 | 1.186 | 1.293 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| Other Hydrocarbons | Styrene | 0.794 | 0.967 | 1.111 | 1.214 | 1.327 | 1.400 | 1.363 | 1.291 | 1.177 | 1.067 | 0.882 | 0.770 |
| | Cumene | 0.796 | 0.969 | 1.096 | 1.196 | 1.326 | 1.390 | 1.345 | 1.276 | 1.175 | 1.056 | 0.869 | 0.771 |
| | MEK | 0.873 | 1.062 | 1.229 | 1.595 | 1.792 | 1.839 | 1.808 | 1.685 | 1.524 | 1.340 | 0.992 | 0.824 |
| | MTBE | 1.065 | 1.165 | 1.334 | 2.251 | 2.480 | 2.386 | 2.338 | 2.156 | 1.989 | 1.786 | 1.106 | 0.892 |
| | Butyl Acrylate | 0.796 | 0.968 | 1.095 | 1.207 | 1.334 | 1.386 | 1.341 | 1.272 | 1.172 | 1.070 | 0.869 | 0.771 |
| | Vinyl Acetate | 0.888 | 1.119 | 1.296 | 1.542 | 1.935 | 2.089 | 2.050 | 1.905 | 1.735 | 1.327 | 1.047 | 0.855 |
| | Xylene | 0.795 | 0.973 | 1.114 | 1.218 | 1.345 | 1.418 | 1.379 | 1.306 | 1.194 | 1.069 | 0.884 | 0.770 |
| | Propyl Acetate | 0.822 | 1.020 | 1.175 | 1.296 | 1.453 | 1.553 | 1.527 | 1.439 | 1.295 | 1.124 | 0.938 | 0.797 |
| | MIBK | 0.796 | 0.969 | 1.109 | 1.223 | 1.342 | 1.423 | 1.388 | 1.313 | 1.194 | 1.073 | 0.882 | 0.771 |
| Petroleum Products NEC | Lube oil | 0.790 | 0.962 | 1.088 | 1.186 | 1.294 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| | Light and Heavy Cycle Oils | 0.790 | 0.962 | 1.088 | 1.186 | 1.294 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |
| Residual Fuel Oil | Residual Fuel | 0.790 | 0.962 | 1.090 | 1.188 | 1.297 | 1.352 | 1.308 | 1.242 | 1.144 | 1.049 | 0.863 | 0.767 |
| | Marine Residual Fuel | 0.792 | 0.967 | 1.096 | 1.201 | 1.316 | 1.375 | 1.334 | 1.265 | 1.160 | 1.058 | 0.869 | 0.770 |
| | No. 6 Fuel Oil | 0.790 | 0.962 | 1.088 | 1.186 | 1.294 | 1.348 | 1.304 | 1.238 | 1.141 | 1.047 | 0.862 | 0.767 |

**Some of these cargos may emit if placed in a 1 pound barge.**
**None of these cargos will emit if placed in a 3 pound barge.**
**No need to model emissions for any of these cargos that are shipped in 3 pound or 6 pound barges.**
**MODEL THIS ENTIRE SET FOR EMISSIONS WHEN SHIPPED IN A 1 POUND BARGE.**

## *Port Arthur*

**Port Arthur Area**
**Evaporation Loss from Low Pressure Tanks**
This formula determines the gauge pressure at which no emissions will occur, given variable inputs for ambient temperature, solar insolation, trip duration, and product vapor pressure.
This formula is based on API Bulletin 2516 - "Evaporation Loss From Low-Pressure Storage Tanks"
**Reference:**
American Petroleum Institute, 2006. API Bulletin 2516 - "Evaporation Loss From Low-Pressure Storage Tanks". March 1962, Reaffirmed February 2006.

P2 = (t2/t1) x (Pa + P1 - p1 ) - (Pa - p2)
where:
P2 = gauge pressure at which the pressure vent opens
Pa = atmospheric pressure at sea level = 14.7
P1 = gauge pressure at which the vacuum vent opens
p1 = true vapor pressure at min. surface temp. (deg. F), in psia
p2 = true vapor pressure at max. surface temp. (deg. F), in psia
t1 = minimum avg. vapor space temperature (degrees R)
t2 = maximum avg. vapor space temperature (degrees R)

| | | | |
|---|---|---|---|
| P2 | | | |
| Pa | 14.7 | 14.7 | 14.7 |
| P1 | 0.0625 | 0.0625 | 0.0625 |
| p1 | varies | varies | varies |
| p2 | varies | varies | varies |
| t1 | varies | varies | varies |
| t2 | varies | varies | varies |

**Assumptions:**
temperature for p1 and t1 = average ambient air temp

| | | Values for P2 in Various Months of the Year for Trip Length = 1 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.142 | 0.165 | 0.156 | 0.158 | 0.182 | 0.186 | 0.186 | 0.186 | 0.181 | 0.162 | 0.171 | 0.143 |
| | n-decane | 0.144 | 0.155 | 0.160 | 0.162 | 0.166 | 0.167 | 0.167 | 0.167 | 0.165 | 0.167 | 0.156 | 0.146 |
| | 1-heptene | 0.142 | 0.167 | 0.156 | 0.157 | 0.184 | 0.184 | 0.183 | 0.184 | 0.183 | 0.162 | 0.167 | 0.143 |
| | hexane | 0.136 | 0.186 | 0.147 | 0.147 | 0.208 | 0.230 | 0.228 | 0.228 | 0.206 | 0.150 | 0.199 | 0.137 |
| | nonene | 0.144 | 0.154 | 0.159 | 0.161 | 0.165 | 0.166 | 0.165 | 0.166 | 0.164 | 0.166 | 0.155 | 0.145 |
| Alcohols | methanol | 0.138 | 0.187 | 0.150 | 0.150 | 0.215 | 0.233 | 0.231 | 0.232 | 0.213 | 0.154 | 0.200 | 0.139 |
| | ethanol | 0.142 | 0.172 | 0.156 | 0.157 | 0.192 | 0.204 | 0.203 | 0.203 | 0.191 | 0.161 | 0.176 | 0.143 |
| | isopropanol | 0.142 | 0.167 | 0.157 | 0.158 | 0.184 | 0.196 | 0.195 | 0.196 | 0.183 | 0.163 | 0.171 | 0.144 |
| | butanols (iso Butyl Alcohol) | 0.144 | 0.157 | 0.159 | 0.161 | 0.171 | 0.176 | 0.175 | 0.176 | 0.170 | 0.166 | 0.160 | 0.145 |
| | decanol | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| | hexanol | 0.144 | 0.155 | 0.160 | 0.162 | 0.167 | 0.167 | 0.167 | 0.168 | 0.166 | 0.167 | 0.157 | 0.146 |
| | 2-ethylhexanol | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| Benzene/Toluene | Benzene | 0.139 | 0.177 | 0.152 | 0.153 | 0.199 | 0.216 | 0.215 | 0.215 | 0.198 | 0.157 | 0.183 | 0.140 |
| | Toluene | 0.143 | 0.162 | 0.158 | 0.160 | 0.177 | 0.181 | 0.181 | 0.181 | 0.176 | 0.164 | 0.165 | 0.144 |
| Carboxylic Acids | acetic acid | 0.144 | 0.158 | 0.159 | 0.161 | 0.171 | 0.172 | 0.172 | 0.172 | 0.171 | 0.166 | 0.159 | 0.145 |
| | propionic acid | 0.144 | 0.156 | 0.160 | 0.162 | 0.166 | 0.167 | 0.170 | 0.170 | 0.165 | 0.167 | 0.156 | 0.146 |
| | butyric acid | 0.144 | 0.155 | 0.160 | 0.162 | 0.166 | 0.167 | 0.167 | 0.168 | 0.166 | 0.167 | 0.155 | 0.146 |
| Chemical Products NEC | Assume non-volatile | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |

| | | Values for P2 in Various Months of the Year for Trip Length = 1 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Chemical Additives | Assume non-volatile | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| Crude Petroleum | crude oil | 0.140 | 0.166 | 0.154 | 0.155 | 0.177 | 0.184 | 0.183 | 0.184 | 0.176 | 0.159 | 0.170 | 0.141 |
| | crude oil RVP 5 | 0.131 | 0.188 | 0.141 | 0.140 | 0.199 | 0.218 | 0.217 | 0.217 | 0.197 | 0.143 | 0.197 | 0.132 |
| Distillate Fuel Oils | #1 diesel | 0.144 | 0.155 | 0.160 | 0.162 | 0.166 | 0.167 | 0.167 | 0.167 | 0.165 | 0.167 | 0.156 | 0.146 |
| | #2 diesel | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| | marine diesel oil | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| | gas oil | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| Gasoline | Gasoline RVP 6 | 0.129 | 0.191 | 0.139 | 0.137 | 0.211 | 0.224 | 0.222 | 0.222 | 0.209 | 0.140 | 0.205 | 0.130 |
| | Gasoline RVP 7 | 0.128 | 0.194 | 0.136 | 0.134 | 0.222 | 0.229 | 0.228 | 0.228 | 0.220 | 0.137 | 0.213 | 0.128 |
| | Gasoline RVP 7.8 | 0.126 | 0.205 | 0.133 | 0.131 | 0.228 | 0.241 | 0.240 | 0.240 | 0.226 | 0.133 | 0.216 | 0.126 |
| | Gasoline RVP 8.3 | 0.125 | 0.208 | 0.131 | 0.129 | 0.232 | 0.245 | 0.244 | 0.244 | 0.229 | 0.131 | 0.220 | 0.125 |
| | Gasoline RVP 10 | 0.120 | 0.225 | 0.125 | 0.122 | 0.238 | 0.254 | 0.252 | 0.252 | 0.235 | 0.123 | 0.222 | 0.120 |
| | Gasoline RVP 11.5 | 0.116 | 0.227 | 0.118 | 0.115 | 0.253 | 0.270 | 0.268 | 0.268 | 0.250 | 0.115 | 0.241 | 0.115 |
| | Gasoline RVP 13 | 0.112 | 0.235 | 0.113 | 0.108 | 0.262 | 0.277 | 0.274 | 0.274 | 0.258 | 0.108 | 0.252 | 0.111 |
| Kerosene | kerosene (Fuel Oil #1) | 0.144 | 0.155 | 0.160 | 0.162 | 0.166 | 0.168 | 0.167 | 0.168 | 0.165 | 0.167 | 0.156 | 0.146 |
| | jet kerosene (Jet A) | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| | jet naphtha (JP-4) | 0.139 | 0.177 | 0.151 | 0.152 | 0.183 | 0.203 | 0.202 | 0.202 | 0.181 | 0.156 | 0.177 | 0.139 |
| Naphtha and Solvents | Naphtha | 0.144 | 0.155 | 0.159 | 0.161 | 0.165 | 0.166 | 0.166 | 0.166 | 0.165 | 0.166 | 0.156 | 0.145 |
| | Coker gas | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| | Cat Gas | 0.139 | 0.177 | 0.151 | 0.152 | 0.183 | 0.203 | 0.202 | 0.202 | 0.181 | 0.156 | 0.177 | 0.139 |
| | Alkylates | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| | 0 | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| Organic Compounds NEC | Assume non-volatile | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| Other Hydrocarbons | Styrene | 0.144 | 0.155 | 0.160 | 0.162 | 0.168 | 0.169 | 0.169 | 0.169 | 0.167 | 0.167 | 0.156 | 0.145 |
| | Cumene | 0.144 | 0.156 | 0.160 | 0.162 | 0.166 | 0.170 | 0.170 | 0.170 | 0.165 | 0.167 | 0.156 | 0.146 |
| | MEK | 0.139 | 0.175 | 0.152 | 0.153 | 0.211 | 0.211 | 0.210 | 0.211 | 0.209 | 0.157 | 0.176 | 0.140 |
| | MTBE | 0.126 | 0.222 | 0.132 | 0.131 | 0.285 | 0.268 | 0.266 | 0.266 | 0.281 | 0.134 | 0.194 | 0.126 |
| | Butyl Acrylate | 0.144 | 0.156 | 0.160 | 0.162 | 0.169 | 0.169 | 0.169 | 0.170 | 0.168 | 0.167 | 0.156 | 0.145 |
| | Vinyl Acetate | 0.139 | 0.178 | 0.151 | 0.151 | 0.205 | 0.235 | 0.234 | 0.234 | 0.203 | 0.155 | 0.189 | 0.140 |
| | Xylene | 0.144 | 0.155 | 0.160 | 0.161 | 0.168 | 0.169 | 0.168 | 0.168 | 0.168 | 0.166 | 0.156 | 0.145 |
| | Propyl Acetate | 0.143 | 0.162 | 0.158 | 0.159 | 0.177 | 0.178 | 0.177 | 0.178 | 0.176 | 0.164 | 0.162 | 0.144 |
| | MIBK | 0.144 | 0.156 | 0.160 | 0.162 | 0.169 | 0.170 | 0.169 | 0.170 | 0.168 | 0.167 | 0.157 | 0.145 |
| Petroleum Products NEC | Lube oil | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| | Light and Heavy Cycle Oils | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| Residual Fuel Oil | Residual Fuel | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |
| | Marine Residual Fuel | 0.144 | 0.155 | 0.160 | 0.162 | 0.167 | 0.168 | 0.168 | 0.168 | 0.166 | 0.167 | 0.156 | 0.146 |
| | No. 6 Fuel Oil | 0.144 | 0.154 | 0.160 | 0.162 | 0.165 | 0.166 | 0.166 | 0.166 | 0.164 | 0.167 | 0.155 | 0.146 |

**None of these cargos will emit on this 1 hour trip when loaded in a 1 pound barge.**
**No need to model emissions for any of these cargos on this trip length.**

| | | Values for P2 in Various Months of the Year for Trip Length = 3 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.315 | 0.356 | 0.383 | 0.387 | 0.398 | 0.433 | 0.432 | 0.406 | 0.395 | 0.408 | 0.369 | 0.318 |
| | n-decane | 0.309 | 0.339 | 0.359 | 0.365 | 0.372 | 0.376 | 0.376 | 0.375 | 0.370 | 0.380 | 0.341 | 0.313 |
| | 1-heptene | 0.317 | 0.360 | 0.376 | 0.380 | 0.402 | 0.427 | 0.425 | 0.401 | 0.398 | 0.407 | 0.361 | 0.320 |
| | hexane | 0.326 | 0.392 | 0.428 | 0.427 | 0.436 | 0.564 | 0.560 | 0.475 | 0.431 | 0.449 | 0.417 | 0.328 |
| | nonene | 0.307 | 0.337 | 0.355 | 0.361 | 0.368 | 0.372 | 0.371 | 0.371 | 0.366 | 0.376 | 0.339 | 0.311 |
| Alcohols | methanol | 0.331 | 0.396 | 0.434 | 0.433 | 0.454 | 0.573 | 0.569 | 0.485 | 0.448 | 0.467 | 0.422 | 0.333 |
| | ethanol | 0.322 | 0.371 | 0.393 | 0.395 | 0.417 | 0.486 | 0.484 | 0.438 | 0.413 | 0.428 | 0.378 | 0.325 |
| | isopropanol | 0.318 | 0.361 | 0.384 | 0.388 | 0.403 | 0.463 | 0.461 | 0.425 | 0.399 | 0.413 | 0.370 | 0.321 |
| | butanols (iso Butyl Alcohol) | 0.311 | 0.343 | 0.365 | 0.370 | 0.380 | 0.402 | 0.400 | 0.390 | 0.378 | 0.389 | 0.349 | 0.314 |
| | decanol | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| | hexanol | 0.309 | 0.339 | 0.360 | 0.365 | 0.373 | 0.377 | 0.377 | 0.376 | 0.370 | 0.381 | 0.344 | 0.313 |
| | 2-ethylhexanol | 0.309 | 0.338 | 0.356 | 0.362 | 0.370 | 0.373 | 0.373 | 0.374 | 0.368 | 0.378 | 0.340 | 0.312 |
| Benzene/Toluene | Benzene | 0.322 | 0.377 | 0.401 | 0.402 | 0.426 | 0.522 | 0.519 | 0.456 | 0.421 | 0.438 | 0.388 | 0.325 |
| | Toluene | 0.314 | 0.352 | 0.373 | 0.377 | 0.390 | 0.418 | 0.417 | 0.399 | 0.387 | 0.399 | 0.357 | 0.318 |
| Carboxylic Acids | acetic acid | 0.311 | 0.344 | 0.358 | 0.375 | 0.381 | 0.391 | 0.390 | 0.383 | 0.378 | 0.389 | 0.346 | 0.315 |
| | propionic acid | 0.310 | 0.340 | 0.358 | 0.364 | 0.372 | 0.379 | 0.384 | 0.380 | 0.369 | 0.379 | 0.343 | 0.313 |
| | butyric acid | 0.309 | 0.338 | 0.358 | 0.363 | 0.371 | 0.377 | 0.377 | 0.376 | 0.371 | 0.379 | 0.341 | 0.312 |
| Chemical Products NEC | Assume non-volatile | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| Chemical Additives | Assume non-volatile | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| Crude Petroleum | crude oil | 0.312 | 0.356 | 0.378 | 0.381 | 0.385 | 0.427 | 0.425 | 0.398 | 0.381 | 0.394 | 0.364 | 0.315 |
| | crude oil RVP 5 | 0.318 | 0.390 | 0.418 | 0.415 | 0.413 | 0.528 | 0.525 | 0.445 | 0.407 | 0.425 | 0.407 | 0.320 |
| Distillate Fuel Oils | #1 diesel | 0.309 | 0.339 | 0.358 | 0.363 | 0.371 | 0.377 | 0.376 | 0.375 | 0.369 | 0.379 | 0.342 | 0.313 |
| | #2 diesel | 0.309 | 0.338 | 0.356 | 0.362 | 0.370 | 0.373 | 0.373 | 0.373 | 0.368 | 0.378 | 0.340 | 0.312 |
| | marine diesel oil | 0.309 | 0.338 | 0.356 | 0.362 | 0.370 | 0.373 | 0.373 | 0.373 | 0.368 | 0.378 | 0.340 | 0.312 |
| | gas oil | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| Gasoline | Gasoline RVP 6 | 0.318 | 0.394 | 0.431 | 0.427 | 0.432 | 0.546 | 0.542 | 0.452 | 0.426 | 0.445 | 0.421 | 0.320 |
| | Gasoline RVP 7 | 0.318 | 0.398 | 0.443 | 0.438 | 0.451 | 0.563 | 0.559 | 0.459 | 0.444 | 0.466 | 0.434 | 0.319 |
| | Gasoline RVP 7.8 | 0.325 | 0.417 | 0.446 | 0.439 | 0.460 | 0.599 | 0.594 | 0.479 | 0.452 | 0.475 | 0.437 | 0.326 |
| | Gasoline RVP 8.3 | 0.326 | 0.421 | 0.450 | 0.443 | 0.464 | 0.611 | 0.606 | 0.483 | 0.456 | 0.480 | 0.443 | 0.326 |
| | Gasoline RVP 10 | 0.335 | 0.450 | 0.449 | 0.440 | 0.468 | 0.637 | 0.631 | 0.491 | 0.460 | 0.485 | 0.442 | 0.334 |
| | Gasoline RVP 11.5 | 0.329 | 0.448 | 0.479 | 0.467 | 0.490 | 0.685 | 0.678 | 0.513 | 0.480 | 0.509 | 0.475 | 0.327 |
| | Gasoline RVP 13 | 0.330 | 0.460 | 0.493 | 0.479 | 0.500 | 0.705 | 0.697 | 0.517 | 0.490 | 0.520 | 0.490 | 0.328 |
| Kerosene | kerosene (Fuel Oil #1) | 0.309 | 0.339 | 0.357 | 0.363 | 0.371 | 0.378 | 0.377 | 0.376 | 0.369 | 0.379 | 0.341 | 0.313 |
| | jet kerosene (Jet A) | 0.309 | 0.338 | 0.356 | 0.362 | 0.370 | 0.374 | 0.373 | 0.374 | 0.368 | 0.378 | 0.340 | 0.312 |
| | jet naphtha (JP-4) | 0.321 | 0.376 | 0.389 | 0.391 | 0.393 | 0.483 | 0.480 | 0.431 | 0.389 | 0.403 | 0.375 | 0.323 |
| Naphtha and Solvents | Naphtha | 0.308 | 0.339 | 0.356 | 0.362 | 0.369 | 0.374 | 0.373 | 0.372 | 0.367 | 0.377 | 0.341 | 0.312 |
| | Coker gas | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| | Cat Gas | 0.321 | 0.376 | 0.389 | 0.391 | 0.393 | 0.483 | 0.480 | 0.431 | 0.389 | 0.403 | 0.375 | 0.323 |

| | | Values for P2 in Various Months of the Year for Trip Length = 3 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Alkylates | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| | 0 | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| Organic Compounds NEC | Assume non-volatile | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| Other Hydrocarbons | Styrene | 0.309 | 0.339 | 0.358 | 0.368 | 0.375 | 0.382 | 0.381 | 0.378 | 0.373 | 0.383 | 0.342 | 0.313 |
| | Cumene | 0.310 | 0.340 | 0.358 | 0.364 | 0.371 | 0.384 | 0.384 | 0.380 | 0.369 | 0.379 | 0.342 | 0.313 |
| | MEK | 0.319 | 0.372 | 0.389 | 0.391 | 0.449 | 0.509 | 0.506 | 0.447 | 0.443 | 0.462 | 0.375 | 0.322 |
| | MTBE | 0.343 | 0.451 | 0.402 | 0.398 | 0.571 | 0.680 | 0.673 | 0.527 | 0.560 | 0.593 | 0.393 | 0.343 |
| | Butyl Acrylate | 0.309 | 0.340 | 0.358 | 0.364 | 0.376 | 0.383 | 0.382 | 0.379 | 0.374 | 0.379 | 0.342 | 0.313 |
| | Vinyl Acetate | 0.322 | 0.378 | 0.413 | 0.414 | 0.436 | 0.580 | 0.576 | 0.492 | 0.431 | 0.449 | 0.401 | 0.325 |
| | Xylene | 0.309 | 0.340 | 0.363 | 0.369 | 0.376 | 0.381 | 0.388 | 0.381 | 0.373 | 0.384 | 0.342 | 0.313 |
| | Propyl Acetate | 0.313 | 0.351 | 0.381 | 0.385 | 0.390 | 0.408 | 0.416 | 0.391 | 0.387 | 0.399 | 0.360 | 0.317 |
| | MIBK | 0.309 | 0.340 | 0.358 | 0.370 | 0.377 | 0.384 | 0.383 | 0.379 | 0.374 | 0.385 | 0.342 | 0.313 |
| Petroleum Products NEC | Lube oil | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| | Light and Heavy Cycle Oils | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |
| Residual Fuel Oil | Residual Fuel | 0.309 | 0.338 | 0.356 | 0.362 | 0.370 | 0.373 | 0.373 | 0.374 | 0.368 | 0.378 | 0.340 | 0.312 |
| | Marine Residual Fuel | 0.309 | 0.338 | 0.358 | 0.364 | 0.373 | 0.379 | 0.378 | 0.377 | 0.370 | 0.380 | 0.342 | 0.313 |
| | No. 6 Fuel Oil | 0.308 | 0.338 | 0.356 | 0.362 | 0.370 | 0.372 | 0.372 | 0.373 | 0.367 | 0.377 | 0.340 | 0.312 |

**None of these cargos will emit on this 3 hour trip when loaded in a 1 pound barge.**
**No need to model emissions for any of these cargos on this trip length.**

| | | Values for P2 in Various Months of the Year for Trip Length = 6 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.833 | 0.929 | 1.025 | 1.050 | 1.101 | 1.148 | 1.116 | 1.119 | 1.102 | 1.099 | 0.961 | 0.843 |
| | n-decane | 0.803 | 0.891 | 0.952 | 0.969 | 0.993 | 1.002 | 0.999 | 1.002 | 0.986 | 1.015 | 0.900 | 0.815 |
| | 1-heptene | 0.842 | 0.940 | 1.003 | 1.045 | 1.106 | 1.156 | 1.139 | 1.142 | 1.095 | 1.105 | 0.942 | 0.852 |
| | hexane | 0.894 | 1.008 | 1.160 | 1.179 | 1.292 | 1.481 | 1.383 | 1.386 | 1.345 | 1.223 | 1.069 | 0.900 |
| | nonene | 0.798 | 0.885 | 0.940 | 0.957 | 0.981 | 0.990 | 0.987 | 0.990 | 0.974 | 1.003 | 0.892 | 0.809 |
| Alcohols | methanol | 0.909 | 1.023 | 1.177 | 1.219 | 1.340 | 1.509 | 1.411 | 1.414 | 1.381 | 1.276 | 1.086 | 0.915 |
| | ethanol | 0.863 | 0.965 | 1.054 | 1.100 | 1.185 | 1.287 | 1.233 | 1.236 | 1.208 | 1.160 | 0.985 | 0.872 |
| | isopropanol | 0.844 | 0.942 | 1.028 | 1.061 | 1.133 | 1.228 | 1.185 | 1.188 | 1.157 | 1.114 | 0.964 | 0.854 |
| | butanols (iso Butyl Alcohol) | 0.810 | 0.900 | 0.969 | 0.992 | 1.031 | 1.068 | 1.053 | 1.056 | 1.035 | 1.041 | 0.916 | 0.822 |
| | decanol | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| | hexanol | 0.804 | 0.894 | 0.954 | 0.971 | 0.995 | 1.005 | 1.001 | 1.004 | 0.988 | 1.017 | 0.904 | 0.816 |
| | 2-ethylhexanol | 0.801 | 0.888 | 0.944 | 0.962 | 0.985 | 0.995 | 0.993 | 0.996 | 0.979 | 1.008 | 0.895 | 0.812 |
| Benzene/Toluene | Benzene | 0.870 | 0.976 | 1.078 | 1.128 | 1.235 | 1.378 | 1.305 | 1.308 | 1.273 | 1.189 | 1.003 | 0.878 |
| | Toluene | 0.827 | 0.921 | 0.993 | 1.021 | 1.068 | 1.110 | 1.087 | 1.090 | 1.071 | 1.073 | 0.935 | 0.838 |

| | | Values for P2 in Various Months of the Year for Trip Length = 6 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Carboxylic Acids | acetic acid | 0.813 | 0.903 | 0.975 | 0.999 | 1.026 | 1.056 | 1.052 | 1.055 | 1.018 | 1.043 | 0.911 | 0.824 |
| | propionic acid | 0.806 | 0.894 | 0.950 | 0.967 | 0.992 | 1.018 | 1.016 | 1.020 | 0.993 | 1.013 | 0.901 | 0.817 |
| | butyric acid | 0.801 | 0.890 | 0.948 | 0.965 | 0.992 | 1.005 | 1.001 | 1.004 | 0.988 | 1.012 | 0.898 | 0.813 |
| Chemical Products NEC | Assume non-volatile | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| Chemical Additives | Assume non-volatile | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| Crude Petroleum | crude oil | 0.829 | 0.925 | 1.008 | 1.017 | 1.064 | 1.128 | 1.095 | 1.098 | 1.075 | 1.057 | 0.945 | 0.838 |
| | crude oil RVP 5 | 0.880 | 0.995 | 1.129 | 1.121 | 1.213 | 1.380 | 1.289 | 1.291 | 1.257 | 1.150 | 1.037 | 0.885 |
| Distillate Fuel Oils | #1 diesel | 0.803 | 0.891 | 0.948 | 0.966 | 0.991 | 1.003 | 0.999 | 1.003 | 0.986 | 1.012 | 0.899 | 0.814 |
| | #2 diesel | 0.801 | 0.888 | 0.944 | 0.962 | 0.985 | 0.995 | 0.992 | 0.996 | 0.979 | 1.008 | 0.896 | 0.813 |
| | marine diesel oil | 0.801 | 0.888 | 0.944 | 0.962 | 0.985 | 0.995 | 0.992 | 0.996 | 0.979 | 1.008 | 0.896 | 0.813 |
| | gas oil | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| Gasoline | Gasoline RVP 6 | 0.885 | 1.002 | 1.167 | 1.175 | 1.275 | 1.423 | 1.320 | 1.322 | 1.302 | 1.211 | 1.067 | 0.889 |
| | Gasoline RVP 7 | 0.890 | 1.009 | 1.205 | 1.229 | 1.337 | 1.465 | 1.351 | 1.353 | 1.346 | 1.272 | 1.097 | 0.893 |
| | Gasoline RVP 7.8 | 0.924 | 1.052 | 1.212 | 1.251 | 1.386 | 1.557 | 1.425 | 1.427 | 1.412 | 1.301 | 1.101 | 0.926 |
| | Gasoline RVP 8.3 | 0.930 | 1.061 | 1.226 | 1.266 | 1.407 | 1.586 | 1.446 | 1.448 | 1.434 | 1.315 | 1.112 | 0.931 |
| | Gasoline RVP 10 | 0.981 | 1.125 | 1.221 | 1.276 | 1.439 | 1.646 | 1.488 | 1.489 | 1.474 | 1.330 | 1.102 | 0.978 |
| | Gasoline RVP 11.5 | 0.968 | 1.113 | 1.313 | 1.355 | 1.533 | 1.764 | 1.577 | 1.578 | 1.567 | 1.402 | 1.175 | 0.964 |
| | Gasoline RVP 13 | 0.984 | 1.135 | 1.355 | 1.393 | 1.576 | 1.809 | 1.605 | 1.607 | 1.604 | 1.436 | 1.206 | 0.978 |
| Kerosene | kerosene (Fuel Oil #1) | 0.803 | 0.890 | 0.946 | 0.966 | 0.992 | 1.005 | 1.001 | 1.005 | 0.987 | 1.013 | 0.897 | 0.814 |
| | jet kerosene (Jet A) | 0.801 | 0.888 | 0.944 | 0.962 | 0.986 | 0.996 | 0.994 | 0.997 | 0.980 | 1.009 | 0.895 | 0.813 |
| | jet naphtha (JP-4) | 0.867 | 0.973 | 1.042 | 1.047 | 1.125 | 1.273 | 1.215 | 1.218 | 1.173 | 1.085 | 0.971 | 0.875 |
| Naphtha and Solvents | Naphtha | 0.801 | 0.888 | 0.944 | 0.961 | 0.985 | 0.995 | 0.991 | 0.994 | 0.978 | 1.007 | 0.895 | 0.812 |
| | Coker gas | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| | Cat Gas | 0.867 | 0.973 | 1.042 | 1.047 | 1.125 | 1.273 | 1.215 | 1.218 | 1.173 | 1.085 | 0.971 | 0.875 |
| | Alkylates | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| | 0 | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| Organic Compounds NEC | Assume non-volatile | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| Other Hydrocarbons | Styrene | 0.804 | 0.892 | 0.958 | 0.979 | 1.004 | 1.019 | 1.016 | 1.019 | 0.997 | 1.024 | 0.901 | 0.815 |
| | Cumene | 0.805 | 0.894 | 0.950 | 0.967 | 0.997 | 1.023 | 1.016 | 1.020 | 0.998 | 1.013 | 0.900 | 0.817 |
| | MEK | 0.860 | 0.964 | 1.042 | 1.164 | 1.283 | 1.341 | 1.272 | 1.275 | 1.272 | 1.260 | 0.972 | 0.868 |
| | MTBE | 0.996 | 1.139 | 1.081 | 1.444 | 1.724 | 1.768 | 1.602 | 1.603 | 1.656 | 1.654 | 0.989 | 0.996 |
| | Butyl Acrylate | 0.805 | 0.893 | 0.949 | 0.966 | 1.009 | 1.020 | 1.013 | 1.017 | 1.002 | 1.016 | 0.900 | 0.816 |
| | Vinyl Acetate | 0.872 | 0.979 | 1.115 | 1.162 | 1.300 | 1.531 | 1.433 | 1.436 | 1.378 | 1.222 | 1.034 | 0.880 |
| | Xylene | 0.804 | 0.892 | 0.965 | 0.981 | 1.007 | 1.035 | 1.032 | 1.035 | 1.005 | 1.026 | 0.907 | 0.815 |
| | Propyl Acetate | 0.825 | 0.918 | 1.019 | 1.031 | 1.062 | 1.120 | 1.108 | 1.112 | 1.062 | 1.073 | 0.951 | 0.835 |
| | MIBK | 0.805 | 0.894 | 0.953 | 0.985 | 1.011 | 1.032 | 1.030 | 1.033 | 1.003 | 1.030 | 0.900 | 0.817 |
| Petroleum Products NEC | Lube oil | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| | Light and Heavy Cycle Oils | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |
| Residual Fuel Oil | Residual Fuel | 0.801 | 0.888 | 0.944 | 0.962 | 0.986 | 0.995 | 0.993 | 0.996 | 0.979 | 1.008 | 0.895 | 0.812 |
| | Marine Residual Fuel | 0.802 | 0.890 | 0.949 | 0.969 | 0.996 | 1.010 | 1.005 | 1.008 | 0.991 | 1.016 | 0.900 | 0.814 |

| | | Values for P2 in Various Months of the Year for Trip Length = 6 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | No. 6 Fuel Oil | 0.800 | 0.888 | 0.943 | 0.961 | 0.984 | 0.992 | 0.990 | 0.994 | 0.977 | 1.007 | 0.895 | 0.812 |

**Some of these cargos may emit if placed in a 1 pound barge.**
**None of these cargos will emit if placed in a 3 pound barge.**
**No need to model emissions for any of these cargos that are shipped in 3 pound or 6 pound barges.**
**MODEL THIS ENTIRE SET FOR EMISSIONS WHEN SHIPPED IN A 1 POUND BARGE.**

## *Corpus Christi*

**Corpus Christi Area**
**Evaporation Loss from Low Pressure Tanks**
This formula determines the gauge pressure at which no emissions will occur, given variable inputs for ambient temperature, solar insolation, trip duration, and product vapor pressure.
This formula is based on API Bulletin 2516 - "Evaporation Loss From Low-Pressure Storage Tanks"
**Reference:**
American Petroleum Institute, 2006. API Bulletin 2516 - "Evaporation Loss From Low-Pressure Storage Tanks". March 1962, Reaffirmed February 2006.

P2 = (t2/t1) x (Pa + P1 - p1 ) - (Pa - p2)
where:
P2 = gauge pressure at which the pressure vent opens
Pa = atmospheric pressure at sea level = 14.7
P1 = gauge pressure at which the vacuum vent opens
p1 = true vapor pressure at min. surface temp. (deg. F), in psia
p2 = true vapor pressure at max. surface temp. (deg. F), in psia
t1 = minimum avg. vapor space temperature (degrees R)
t2 = maximum avg. vapor space temperature (degrees R)

| | | | |
|---|---|---|---|
| P2 | | | |
| Pa | 14.7 | 14.7 | 14.7 |
| P1 | 0.0625 | 0.0625 | 0.0625 |
| p1 | varies | varies | varies |
| p2 | varies | varies | varies |
| t1 | varies | varies | varies |
| t2 | varies | varies | varies |

**Assumptions:**
temperature for p1 and t1 = average ambient air temp

| | | Values for P2 in Various Months of the Year for Trip Length = 5 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 1.065 | 1.272 | 1.437 | 1.579 | 1.684 | 1.897 | 2.024 | 1.850 | 1.631 | 1.445 | 1.164 | 1.042 |
| | n-decane | 1.027 | 1.190 | 1.334 | 1.426 | 1.498 | 1.635 | 1.725 | 1.610 | 1.428 | 1.308 | 1.097 | 0.993 |
| | 1-heptene | 1.070 | 1.251 | 1.424 | 1.602 | 1.698 | 1.940 | 2.081 | 1.901 | 1.663 | 1.454 | 1.135 | 1.035 |
| | hexane | 1.139 | 1.421 | 1.605 | 1.826 | 2.075 | 2.448 | 2.625 | 2.340 | 2.084 | 1.680 | 1.281 | 1.130 |
| | nonene | 1.019 | 1.178 | 1.318 | 1.408 | 1.480 | 1.614 | 1.703 | 1.590 | 1.410 | 1.292 | 1.084 | 0.985 |
| Alcohols | methanol | 1.159 | 1.443 | 1.654 | 1.904 | 2.130 | 2.526 | 2.729 | 2.426 | 2.132 | 1.746 | 1.308 | 1.149 |
| | ethanol | 1.099 | 1.308 | 1.497 | 1.689 | 1.853 | 2.158 | 2.328 | 2.098 | 1.830 | 1.551 | 1.197 | 1.071 |
| | isopropanol | 1.077 | 1.278 | 1.450 | 1.611 | 1.772 | 2.041 | 2.188 | 1.987 | 1.745 | 1.482 | 1.170 | 1.050 |
| | butanols (iso Butyl Alcohol) | 1.037 | 1.210 | 1.363 | 1.476 | 1.577 | 1.755 | 1.863 | 1.722 | 1.520 | 1.356 | 1.114 | 1.006 |
| | decanol | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| | hexanol | 1.031 | 1.195 | 1.337 | 1.429 | 1.502 | 1.639 | 1.734 | 1.612 | 1.431 | 1.311 | 1.099 | 0.999 |
| | 2-ethylhexanol | 1.024 | 1.183 | 1.324 | 1.415 | 1.488 | 1.623 | 1.713 | 1.600 | 1.418 | 1.298 | 1.089 | 0.990 |
| Benzene/Toluene | Benzene | 1.106 | 1.334 | 1.531 | 1.752 | 1.957 | 2.249 | 2.387 | 2.156 | 1.939 | 1.611 | 1.216 | 1.082 |
| | Toluene | 1.056 | 1.238 | 1.399 | 1.531 | 1.634 | 1.822 | 1.935 | 1.781 | 1.577 | 1.404 | 1.137 | 1.025 |
| Carboxylic Acids | acetic acid | 1.037 | 1.209 | 1.374 | 1.476 | 1.565 | 1.757 | 1.874 | 1.732 | 1.517 | 1.351 | 1.126 | 1.003 |
| | propionic acid | 1.029 | 1.190 | 1.332 | 1.424 | 1.513 | 1.666 | 1.761 | 1.640 | 1.450 | 1.306 | 1.095 | 0.995 |

| | | Values for P2 in Various Months of the Year for Trip Length = 5 hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | butyric acid | 1.025 | 1.186 | 1.329 | 1.423 | 1.501 | 1.639 | 1.729 | 1.614 | 1.431 | 1.306 | 1.093 | 0.992 |
| Chemical Products NEC | Assume non-volatile | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| Chemical Additives | Assume non-volatile | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| Crude Petroleum | crude oil | 1.055 | 1.252 | 1.396 | 1.519 | 1.643 | 1.846 | 1.959 | 1.795 | 1.598 | 1.395 | 1.139 | 1.028 |
| | crude oil RVP 5 | 1.114 | 1.383 | 1.533 | 1.716 | 1.936 | 2.268 | 2.425 | 2.165 | 1.938 | 1.577 | 1.233 | 1.100 |
| Distillate Fuel Oils | #1 diesel | 1.026 | 1.187 | 1.329 | 1.422 | 1.498 | 1.639 | 1.732 | 1.615 | 1.429 | 1.305 | 1.093 | 0.993 |
| | #2 diesel | 1.024 | 1.183 | 1.324 | 1.415 | 1.487 | 1.623 | 1.713 | 1.600 | 1.417 | 1.298 | 1.090 | 0.990 |
| | marine diesel oil | 1.024 | 1.183 | 1.324 | 1.415 | 1.487 | 1.623 | 1.713 | 1.600 | 1.417 | 1.298 | 1.090 | 0.990 |
| | gas oil | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| Gasoline | Gasoline RVP 6 | 1.123 | 1.422 | 1.598 | 1.819 | 2.008 | 2.354 | 2.530 | 2.245 | 1.998 | 1.660 | 1.270 | 1.118 |
| | Gasoline RVP 7 | 1.131 | 1.461 | 1.663 | 1.921 | 2.080 | 2.440 | 2.635 | 2.324 | 2.058 | 1.744 | 1.308 | 1.137 |
| | Gasoline RVP 7.8 | 1.163 | 1.476 | 1.686 | 1.982 | 2.185 | 2.577 | 2.774 | 2.441 | 2.179 | 1.803 | 1.314 | 1.154 |
| | Gasoline RVP 8.3 | 1.170 | 1.491 | 1.704 | 2.011 | 2.221 | 2.626 | 2.829 | 2.483 | 2.218 | 1.829 | 1.325 | 1.162 |
| | Gasoline RVP 10 | 1.211 | 1.495 | 1.708 | 2.055 | 2.286 | 2.764 | 3.006 | 2.613 | 2.306 | 1.868 | 1.312 | 1.175 |
| | Gasoline RVP 11.5 | 1.208 | 1.583 | 1.814 | 2.191 | 2.437 | 2.922 | 3.157 | 2.737 | 2.455 | 1.987 | 1.389 | 1.209 |
| | Gasoline RVP 13 | 1.225 | 1.628 | 1.862 | 2.259 | 2.497 | 3.016 | 3.274 | 2.821 | 2.518 | 2.042 | 1.420 | 1.231 |
| Kerosene | kerosene (Fuel Oil #1) | 1.026 | 1.186 | 1.329 | 1.423 | 1.500 | 1.642 | 1.735 | 1.618 | 1.432 | 1.306 | 1.092 | 0.992 |
| | jet kerosene (Jet A) | 1.024 | 1.183 | 1.324 | 1.416 | 1.489 | 1.625 | 1.716 | 1.602 | 1.419 | 1.299 | 1.090 | 0.990 |
| | jet naphtha (JP-4) | 1.097 | 1.295 | 1.436 | 1.583 | 1.800 | 1.983 | 2.039 | 1.883 | 1.770 | 1.465 | 1.168 | 1.061 |
| Naphtha and Solvents | Naphtha | 1.023 | 1.183 | 1.323 | 1.415 | 1.487 | 1.622 | 1.712 | 1.597 | 1.416 | 1.297 | 1.088 | 0.989 |
| | Coker gas | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| | Cat Gas | 1.097 | 1.295 | 1.436 | 1.583 | 1.800 | 1.983 | 2.039 | 1.883 | 1.770 | 1.465 | 1.168 | 1.061 |
| | Alkylates | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| | 0 | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| Organic Compounds NEC | Assume non-volatile | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| Organo-Inorganic Cmpds | Assume non-volatile | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |
| Other Hydrocarbons | Styrene | 1.027 | 1.192 | 1.347 | 1.443 | 1.520 | 1.680 | 1.783 | 1.656 | 1.459 | 1.322 | 1.107 | 0.992 |
| | Cumene | 1.029 | 1.190 | 1.331 | 1.426 | 1.518 | 1.668 | 1.761 | 1.640 | 1.456 | 1.311 | 1.094 | 0.995 |
| | MEK | 1.090 | 1.294 | 1.553 | 1.853 | 1.955 | 2.204 | 2.350 | 2.120 | 1.891 | 1.683 | 1.198 | 1.059 |
| | MTBE | 1.209 | 1.359 | 1.834 | 2.537 | 2.570 | 2.845 | 3.010 | 2.655 | 2.449 | 2.263 | 1.265 | 1.120 |
| | Butyl Acrylate | 1.028 | 1.189 | 1.330 | 1.439 | 1.523 | 1.663 | 1.759 | 1.635 | 1.452 | 1.324 | 1.094 | 0.994 |
| | Vinyl Acetate | 1.114 | 1.372 | 1.577 | 1.822 | 2.125 | 2.500 | 2.659 | 2.384 | 2.149 | 1.687 | 1.250 | 1.101 |
| | Xylene | 1.027 | 1.199 | 1.350 | 1.446 | 1.537 | 1.699 | 1.804 | 1.676 | 1.477 | 1.326 | 1.109 | 0.995 |
| | Propyl Acetate | 1.050 | 1.258 | 1.417 | 1.530 | 1.643 | 1.854 | 1.981 | 1.822 | 1.600 | 1.398 | 1.158 | 1.030 |
| | MIBK | 1.029 | 1.190 | 1.353 | 1.452 | 1.536 | 1.706 | 1.813 | 1.682 | 1.479 | 1.331 | 1.107 | 0.995 |
| Petroleum Products NEC | Lube oil | 1.023 | 1.182 | 1.323 | 1.413 | 1.484 | 1.618 | 1.708 | 1.596 | 1.414 | 1.296 | 1.089 | 0.989 |
| | Light and Heavy Cycle Oils | 1.023 | 1.182 | 1.323 | 1.413 | 1.484 | 1.618 | 1.708 | 1.596 | 1.414 | 1.296 | 1.089 | 0.989 |
| Residual Fuel Oil | Residual Fuel | 1.024 | 1.183 | 1.324 | 1.415 | 1.488 | 1.623 | 1.714 | 1.600 | 1.418 | 1.298 | 1.090 | 0.990 |
| | Marine Residual Fuel | 1.026 | 1.188 | 1.333 | 1.429 | 1.506 | 1.652 | 1.747 | 1.627 | 1.439 | 1.311 | 1.095 | 0.993 |
| | No. 6 Fuel Oil | 1.023 | 1.182 | 1.323 | 1.412 | 1.484 | 1.618 | 1.708 | 1.595 | 1.414 | 1.296 | 1.089 | 0.989 |

**Some of these cargos may emit if placed in a 1 pound barge.**
**None of these cargos will emit if placed in a 3 pound barge.**
**No need to model emissions for any of these cargos that are shipped in 3 pound or 6 pound barges.**
**MODEL THIS ENTIRE SET FOR EMISSIONS WHEN SHIPPED IN A 1 POUND BARGE.**

# Appendix C
# Barge Liquid Heat Transfer: Example Calculation

The following presents the methodology used to estimate the heat transfer from fluids stored in barges. In this evaluation, a barge carries a fluid chemical (similar to a tanker) from one point to another. The barge travels through a bay or ocean, which may be warmer or cooler than the fluid stored within the barge, depending upon location and the time of year. The purpose of this modeling work was to determine the heat transfer rate between the stored fluid and the surrounding seawater during the barge's transit time. A simple model is presented that calculates the fluid temperature as a function of time for a given seawater temperature and initial liquid temperature.

Figure C-1 below illustrates a cross-sectional view of the barge of interest. It is assumed that the barge has a double hull system: an inner hull, an outer hull, and a space between the two hulls. It is further assumed that the fluid level within the barge is completely submerged below the surrounding seawater level.

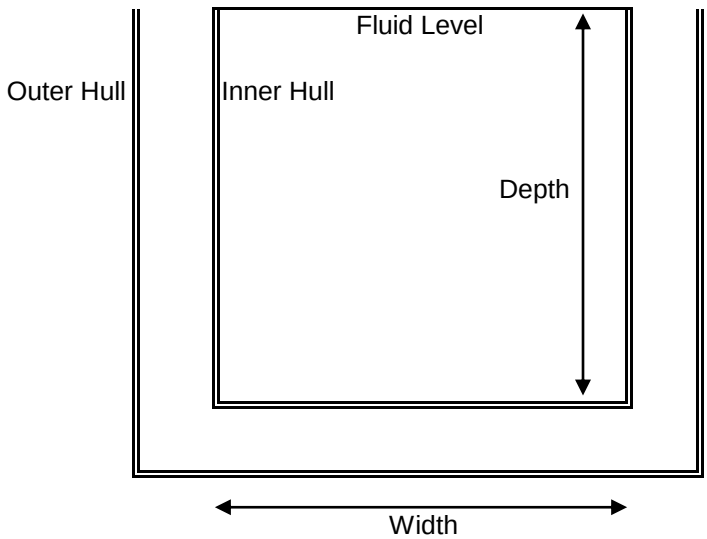


**Figure C-1. Simplified Cross-Sectional View of the Barge**

Figure C-2 illustrates the heat flow from the fluid through the double hull and into the surrounding seawater. It is assumed that the space between the two hulls is filled with water.[34]

[34] The presence of air in between the two hulls will increase the insulating effect.

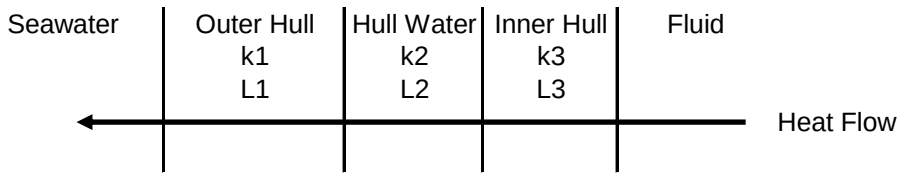


**Figure C-2. Illustration of Heat Flow through a Double Hull**

The fluid within the barge is modeled using the "lumped capacitance" approach. In this approach, the temperature of the fluid is assumed to be spatially uniform; hence, temperature gradients within the fluid are negligible. This assumption predicts the fluid to be a consistent temperature throughout at any instant in time. This assumption is valid for substances in which the resistance to heat transfer within the substance is negligible compared to the resistance to heat transfer between the substance and its surroundings. In general, this assumption may be deemed valid if the resistance to heat transfer within the fluid is less than 10 percent of the resistance to heat transfer between the substance and its surroundings. This can be determined by analyzing the Biot number (*Bi*) of the system. A quantitative analysis is not presented here, but a qualitative discussion is provided below.

In general, it is unlikely that this assumption is valid for fluids, which generally show higher resistances to heat transfer. Specifically, it is unlikely that the fluid stored within the barge would have a lower resistance to heat transfer than the surrounding hull unless the hull was sufficiently insulated. Furthermore, it is unlikely that the fluid within a barge would maintain a spatially uniform temperature as heat is removed from the initially spatially isothermal fluid. However, using the lumped capacitance assumption provides a worst-case estimate. By neglecting the resistance to heat transfer within the fluid, this model estimates a faster heat transfer time for the fluid to approach the temperature of the seawater. Described in another way, this model predicts the lowest local temperature of the fluid (i.e., closest to the hull) and assumes the entire fluid body is equal to this temperature.

The heat balance for a substance using the lumped capacitance approach is as follows:

$$\rho V C_P \frac{dT}{dt} = q \text{ (Equation 1)}$$

Where:

T = Temperature of the substance (fluid within the barge) at any instant in time;

| | | |
|---|---|---|
| $\rho$ | = | Mass density of the substance (fluid within the barge); |
| $C_P$ | = | Mass-specific heat capacity of the substance (fluid within the barge); |
| V | = | Volume of the substance (fluid within the barge); and |
| q | = | Heat transferred to the surroundings. |

For the barge system illustrated in Figure C-1, heat is transferred to the surroundings by conduction through the barge hull. Recognizing that the hull is a composite material, conduction is modeled as follows:

$$q = A_S k \frac{dT}{dx} = -A_S k \frac{T - T_\infty}{L} = -\frac{T - T_\infty}{\sum R_T} \text{ (Equation 2)}$$

Where:

| | | |
|---|---|---|
| k | = | Thermal conductivity of the hull; |
| $T_\infty$ | = | Temperature of the surroundings (the seawater), assumed to be an infinite heat sink such that its temperature remains constant; |
| L | = | Characteristic length (thickness) of the hull; |
| $A_S$ | = | Surface area of fluid in contact with the inner hull; and |
| $R_T$ | = | Thermal resistance. |

As illustrated in Figure C-2, this approach assumes the barge has a double hull, which consists of an inner hull and outer hull separated by a space. It is assumed that the space between the inner and outer hull is occupied by water. It is further assumed that the inner and outer hulls are both made of stainless steel. To simplify the model, the double hull is reduced to these two components: stainless steel and water in between the two hull layers. The total thermal resistance is calculated as:

$$\sum R_T = \sum_j \frac{L_j}{k_j A_j} = \left[ \frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3} \right] \frac{1}{A_S} \text{ (Equation 3)}$$

Where:

| | | |
|---|---|---|
| $L_1$ | = | Characteristic length (thickness) of the outer hull; |
| $k_1$ | = | Thermal conductivity of the outer hull (assumed to be equal to stainless steel); |
| $L_2$ | = | Characteristic length (thickness) of the hull water; |
| $k_2$ | = | Thermal conductivity of the hull water (assumed to be equal to pure water); |
| $L_3$ | = | Characteristic length (thickness) of the inner hull; |

| | | |
|---|---|---|
| $k_3$ | = | Thermal conductivity of the inner hull (assumed to be equal to stainless steel); and |
| $A_S$ | = | Surface area of the fluid in contact with the inner hull. |

Note that the surface area of the fluid in contact with the inner hull, the surface area of the inner hull in contact with the hull water, and the surface area of the hull water in contact with the outer hull are all assumed equal to each other. This assumption essentially neglects the corners of the barge and assumes the hull consists of five plane walls. The five plane walls are: the bottom of the hull, the two lengthwise sides of the hull, and the front and back of the hull.

To solve, we now define the following:

$$\theta = T - T_\infty \text{ (Equation 4)}$$

And recognizing that:

$$\frac{d\theta}{dt} = \frac{dT}{dt} \text{ (Equation 5)}$$

We substitute Equations 2, 4, and 5 into Equation 1 and arrive at (dropping the summation of $R_T$ for brevity):

$$R_T \rho V C_P \frac{d\theta}{dt} = -\theta \text{ (Equation 6)}$$

Integrating from the initial temperature ($T_i$ or $\theta_i$) and initial time to the temperature and time of interest:

$$\int_{\theta_i}^{\theta} \frac{d\theta}{\theta} = \int_0^t -\frac{dt}{R_T \rho V C_P} \text{ (Equation 7)}$$

$$\frac{\theta}{\theta_i} = \frac{T - T_\infty}{T_i - T_\infty} = \exp\left[-\frac{t}{R_T \rho V C_P}\right] \text{(Equation 8)}$$

The final equation to describe the fluid temperature as a function of time is:

$$T = (T_i - T_\infty)\exp\left[-\frac{t}{R_T \rho V C_P}\right] + T_\infty \text{ (Equation 9)}$$

ERG utilized the above equation to estimate the change in temperature for the following set of input assumptions:

- Initial liquid temperature – 90F

- Water temperature – 70F
- Liquid heat capacity – 1.728 kJ/kg-K (benzene)
- Barge volume – 30,000 barrel
- Hull thickness – 7/16 inch (see http://cfr.vlex.com/vid/157-double-hulls-tank-vessels-19763160)
- Width between inner and outer hull – 30 inches (see http://cfr.vlex.com/vid/157-double-hulls-tank-vessels-19763160)
- Barge dimensions – 277.6' x 58' x 13.6' (see http://cfr.vlex.com/vid/157-double-hulls-tank-vessels-19763160)

Given the above inputs we calculate that liquid temperatures will fall by approximately 0.2F over a 12 hour period, assuming no other thermal influences on the system. Accordingly, ERG concludes that thermal exchange between liquid product and the surrounding water is not significant for loaded barges. As such ERG only proposes to model liquid temperature changes associated with solar insolation.

**Reference:** Incropera, Frank P.; DeWitt, David P. *Fundamentals of Heat and Mass Transfer*, 5th Ed. John Wiley & Sons: New York, 2002.

# Appendix D
# Vapor Space Saturation Factors

## *Loaded*

**VENTED VAPOR SATURATION FACTOR ( Ks ) - LOADED BARGES**

Ks = 1 / ( 1 + 0.053 Pva Hvo )

where:

Ks = vented vapor saturation factor, dimensionless

Pva = vapor pressure at daily average liquid surface temperature, psia

Hvo = vapor space outage, ft **0.3**

0.053 = constant, (psia-ft)-1 **0.053**

| | | | Houston – Loaded | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 511.8 | 515.4 | 522.3 | 528.5 | 535.8 | 541.3 | 543.6 | 543.3 | 538.9 | 530.4 | 520.9 | 513.7 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | | **Δ Tv** | **6.03** | **6.76** | **7.20** | **7.36** | **7.58** | **7.75** | **7.82** | **7.83** | **7.69** | **7.83** | **6.81** | **6.14** |
| | | **Tla** | **512.69** | **516.51** | **523.60** | **529.92** | **537.37** | **542.94** | **545.21** | **544.87** | **540.37** | **531.77** | **521.97** | **514.57** |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 2 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 100.2 | 0.9932 | 0.9923 | 0.9906 | 0.9887 | 0.9859 | 0.9840 | 0.9828 | 0.9832 | 0.9849 | 0.9881 | 0.9912 | 0.9927 |
| | n-decane | 142.29 | 0.9998 | 0.9998 | 0.9997 | 0.9995 | 0.9993 | 0.9992 | 0.9991 | 0.9991 | 0.9992 | 0.9995 | 0.9997 | 0.9998 |
| | 1-heptene | 98.19 | 0.9926 | 0.9916 | 0.9898 | 0.9883 | 0.9854 | 0.9834 | 0.9823 | 0.9827 | 0.9842 | 0.9879 | 0.9903 | 0.9921 |
| | hexane | 86.17 | 0.9762 | 0.9736 | 0.9685 | 0.9635 | 0.9564 | 0.9512 | 0.9476 | 0.9488 | 0.9537 | 0.9618 | 0.9702 | 0.9749 |
| | nonene | 126.24 | 0.9979 | 0.9978 | 0.9977 | 0.9976 | 0.9975 | 0.9974 | 0.9974 | 0.9974 | 0.9975 | 0.9976 | 0.9978 | 0.9979 |
| Alcohols | methanol | 32.04 | 0.9830 | 0.9805 | 0.9756 | 0.9707 | 0.9631 | 0.9577 | 0.9540 | 0.9552 | 0.9602 | 0.9689 | 0.9772 | 0.9818 |
| | ethanol | 46.07 | 0.9929 | 0.9916 | 0.9891 | 0.9867 | 0.9826 | 0.9796 | 0.9775 | 0.9782 | 0.9810 | 0.9858 | 0.9899 | 0.9923 |
| | isopropanol | 60.09 | 0.9943 | 0.9933 | 0.9915 | 0.9897 | 0.9866 | 0.9843 | 0.9826 | 0.9832 | 0.9855 | 0.9890 | 0.9921 | 0.9938 |
| | butanols (iso Butyl Alcohol) | 74.12 | 0.9983 | 0.9981 | 0.9976 | 0.9970 | 0.9961 | 0.9953 | 0.9948 | 0.9950 | 0.9957 | 0.9968 | 0.9978 | 0.9982 |
| | decanol | 158.28 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | hexanol | 102.18 | 0.9998 | 0.9997 | 0.9995 | 0.9993 | 0.9991 | 0.9989 | 0.9988 | 0.9988 | 0.9989 | 0.9993 | 0.9996 | 0.9998 |
| | 2-ethylhexanol | 130.2 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| Benzene/Toluene | Benzene | 78.11 | 0.9855 | 0.9837 | 0.9803 | 0.9771 | 0.9717 | 0.9677 | 0.9649 | 0.9658 | 0.9696 | 0.9759 | 0.9814 | 0.9846 |
| | Toluene | 92.13 | 0.9963 | 0.9957 | 0.9946 | 0.9935 | 0.9916 | 0.9903 | 0.9894 | 0.9897 | 0.9909 | 0.9930 | 0.9949 | 0.9960 |
| Carboxylic Acids | acetic acid | 60.05 | 0.9978 | 0.9975 | 0.9969 | 0.9962 | 0.9951 | 0.9944 | 0.9940 | 0.9942 | 0.9947 | 0.9959 | 0.9971 | 0.9976 |
| | propionic acid | 74.08 | 0.9993 | 0.9992 | 0.9990 | 0.9988 | 0.9986 | 0.9985 | 0.9982 | 0.9983 | 0.9985 | 0.9988 | 0.9991 | 0.9993 |
| | butyric acid | 88.12 | 1.0000 | 1.0000 | 0.9999 | 0.9998 | 0.9997 | 0.9996 | 0.9995 | 0.9995 | 0.9996 | 0.9998 | 0.9999 | 1.0000 |
| Chemical Products NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Chemical Additives | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Crude Petroleum | crude oil | 50 | 0.9868 | 0.9857 | 0.9836 | 0.9817 | 0.9791 | 0.9773 | 0.9760 | 0.9765 | 0.9782 | 0.9811 | 0.9843 | 0.9862 |
| | crude oil RVP 5 | 50 | 0.9632 | 0.9603 | 0.9548 | 0.9496 | 0.9427 | 0.9380 | 0.9346 | 0.9357 | 0.9402 | 0.9479 | 0.9565 | 0.9618 |
| Distillate Fuel Oils | #1 diesel | 180 | 0.9997 | 0.9996 | 0.9995 | 0.9994 | 0.9992 | 0.9991 | 0.9990 | 0.9991 | 0.9992 | 0.9994 | 0.9995 | 0.9996 |
| | #2 diesel | 130 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| | marine diesel oil | 130 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| | gas oil | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| | | | Houston – Loaded | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 511.8 | 515.4 | 522.3 | 528.5 | 535.8 | 541.3 | 543.6 | 543.3 | 538.9 | 530.4 | 520.9 | 513.7 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | | **Δ Tv** | **6.03** | **6.76** | **7.20** | **7.36** | **7.58** | **7.75** | **7.82** | **7.83** | **7.69** | **7.83** | **6.81** | **6.14** |
| | | **Tla** | **512.69** | **516.51** | **523.60** | **529.92** | **537.37** | **542.94** | **545.21** | **544.87** | **540.37** | **531.77** | **521.97** | **514.57** |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 2 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Gasoline | Gasoline RVP 6 | 68 | 0.9587 | 0.9555 | 0.9493 | 0.9433 | 0.9350 | 0.9294 | 0.9257 | 0.9269 | 0.9318 | 0.9413 | 0.9513 | 0.9571 |
| | Gasoline RVP 7 | 68 | 0.9542 | 0.9507 | 0.9439 | 0.9371 | 0.9273 | 0.9209 | 0.9169 | 0.9182 | 0.9236 | 0.9348 | 0.9461 | 0.9524 |
| | Gasoline RVP 7.8 | 68 | 0.9494 | 0.9452 | 0.9375 | 0.9304 | 0.9197 | 0.9126 | 0.9080 | 0.9095 | 0.9157 | 0.9278 | 0.9399 | 0.9473 |
| | Gasoline RVP 8.3 | 68 | 0.9459 | 0.9415 | 0.9333 | 0.9258 | 0.9146 | 0.9072 | 0.9024 | 0.9040 | 0.9104 | 0.9232 | 0.9359 | 0.9437 |
| | Gasoline RVP 10 | 66 | 0.9346 | 0.9291 | 0.9196 | 0.9116 | 0.8993 | 0.8912 | 0.8859 | 0.8877 | 0.8947 | 0.9087 | 0.9223 | 0.9318 |
| | Gasoline RVP 11.5 | 65 | 0.9235 | 0.9177 | 0.9071 | 0.8974 | 0.8832 | 0.8738 | 0.8678 | 0.8698 | 0.8778 | 0.8940 | 0.9104 | 0.9206 |
| | Gasoline RVP 13 | 62 | 0.9137 | 0.9074 | 0.8957 | 0.8852 | 0.8697 | 0.8597 | 0.8534 | 0.8555 | 0.8640 | 0.8814 | 0.8993 | 0.9105 |
| Kerosene | kerosene (Fuel Oil #1) | 170 | 0.9996 | 0.9996 | 0.9995 | 0.9994 | 0.9992 | 0.9991 | 0.9990 | 0.9990 | 0.9992 | 0.9994 | 0.9995 | 0.9996 |
| | jet kerosene (Jet A) | 130 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9997 | 0.9998 | 0.9998 | 0.9999 | 0.9999 |
| | jet naphtha (JP-4) | 80 | 0.9834 | 0.9816 | 0.9784 | 0.9756 | 0.9720 | 0.9692 | 0.9669 | 0.9677 | 0.9707 | 0.9747 | 0.9793 | 0.9825 |
| Naphtha and Solvents | Naphtha | 110 | 0.9974 | 0.9973 | 0.9970 | 0.9968 | 0.9965 | 0.9964 | 0.9963 | 0.9963 | 0.9964 | 0.9967 | 0.9971 | 0.9973 |
| | Coker gas | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Cat Gas | 80 | 0.9834 | 0.9816 | 0.9784 | 0.9756 | 0.9720 | 0.9692 | 0.9669 | 0.9677 | 0.9707 | 0.9747 | 0.9793 | 0.9825 |
| | Alkylates | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organic Compounds NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Other Hydrocarbons | Styrene | 104.14 | 0.9988 | 0.9987 | 0.9985 | 0.9981 | 0.9976 | 0.9973 | 0.9971 | 0.9971 | 0.9974 | 0.9980 | 0.9985 | 0.9987 |
| | Cumene | 120.2 | 0.9993 | 0.9991 | 0.9989 | 0.9988 | 0.9986 | 0.9983 | 0.9981 | 0.9982 | 0.9985 | 0.9987 | 0.9990 | 0.9992 |
| | MEK | 72.1 | 0.9846 | 0.9830 | 0.9800 | 0.9773 | 0.9708 | 0.9664 | 0.9637 | 0.9646 | 0.9682 | 0.9760 | 0.9808 | 0.9838 |
| | MTBE | 88.15 | 0.9492 | 0.9441 | 0.9362 | 0.9308 | 0.9149 | 0.9048 | 0.8991 | 0.9010 | 0.9086 | 0.9277 | 0.9380 | 0.9466 |
| | Butyl Acrylate | 128.17 | 0.9991 | 0.9990 | 0.9988 | 0.9986 | 0.9983 | 0.9979 | 0.9977 | 0.9978 | 0.9981 | 0.9986 | 0.9988 | 0.9990 |
| | Vinyl Acetate | 86.09 | 0.9836 | 0.9817 | 0.9779 | 0.9740 | 0.9677 | 0.9628 | 0.9590 | 0.9603 | 0.9653 | 0.9726 | 0.9792 | 0.9827 |
| | Xylene | 106.17 | 0.9988 | 0.9986 | 0.9984 | 0.9979 | 0.9974 | 0.9970 | 0.9967 | 0.9968 | 0.9971 | 0.9978 | 0.9985 | 0.9987 |
| | Propyl Acetate | 102.13 | 0.9953 | 0.9947 | 0.9934 | 0.9918 | 0.9897 | 0.9884 | 0.9874 | 0.9879 | 0.9889 | 0.9912 | 0.9939 | 0.9950 |
| | MIBK | 100.16 | 0.9990 | 0.9988 | 0.9986 | 0.9983 | 0.9977 | 0.9973 | 0.9970 | 0.9971 | 0.9974 | 0.9981 | 0.9987 | 0.9989 |
| Petroleum Products NEC | Lube oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Light and Heavy Cycle Oils | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Residual Fuel Oil | Residual Fuel | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 | 0.9999 |
| | Marine Residual Fuel | 190 | 0.9997 | 0.9996 | 0.9995 | 0.9994 | 0.9991 | 0.9990 | 0.9988 | 0.9989 | 0.9990 | 0.9993 | 0.9996 | 0.9996 |
| | No. 6 Fuel Oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| | | | Galveston - Loaded | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 515.8 | 518 | 524.1 | 530 | 536.9 | 542.2 | 544.3 | 544.4 | 541.1 | 534.1 | 525.4 | 518.1 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | | **Δ Tv** | 4.82 | 5.58 | 6.00 | 6.18 | 6.50 | 6.72 | 6.65 | 6.64 | 6.51 | 6.31 | 5.40 | 4.83 |
| | | **Tla** | 516.69 | 519.11 | 525.40 | 531.42 | 538.47 | 543.84 | 545.91 | 545.97 | 542.57 | 535.47 | 526.47 | 518.97 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 2 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 100.2 | 0.9923 | 0.9917 | 0.9900 | 0.9881 | 0.9856 | 0.9836 | 0.9828 | 0.9828 | 0.9840 | 0.9866 | 0.9897 | 0.9919 |
| | n-decane | 142.29 | 0.9998 | 0.9997 | 0.9996 | 0.9995 | 0.9993 | 0.9991 | 0.9991 | 0.9991 | 0.9992 | 0.9993 | 0.9996 | 0.9997 |
| | 1-heptene | 98.19 | 0.9916 | 0.9908 | 0.9893 | 0.9879 | 0.9850 | 0.9831 | 0.9823 | 0.9823 | 0.9834 | 0.9862 | 0.9891 | 0.9911 |
| | hexane | 86.17 | 0.9736 | 0.9717 | 0.9669 | 0.9618 | 0.9555 | 0.9500 | 0.9476 | 0.9476 | 0.9512 | 0.9582 | 0.9660 | 0.9723 |
| | nonene | 126.24 | 0.9978 | 0.9978 | 0.9977 | 0.9976 | 0.9975 | 0.9974 | 0.9974 | 0.9974 | 0.9974 | 0.9975 | 0.9977 | 0.9978 |
| Alcohols | methanol | 32.04 | 0.9805 | 0.9787 | 0.9739 | 0.9689 | 0.9621 | 0.9564 | 0.9540 | 0.9540 | 0.9577 | 0.9650 | 0.9731 | 0.9793 |
| | ethanol | 46.07 | 0.9916 | 0.9906 | 0.9883 | 0.9858 | 0.9821 | 0.9789 | 0.9775 | 0.9775 | 0.9796 | 0.9837 | 0.9879 | 0.9909 |
| | isopropanol | 60.09 | 0.9933 | 0.9926 | 0.9909 | 0.9890 | 0.9862 | 0.9838 | 0.9826 | 0.9826 | 0.9843 | 0.9874 | 0.9906 | 0.9929 |
| | butanols (iso Butyl Alcohol) | 74.12 | 0.9981 | 0.9979 | 0.9974 | 0.9968 | 0.9960 | 0.9952 | 0.9948 | 0.9948 | 0.9953 | 0.9963 | 0.9973 | 0.9980 |
| | decanol | 158.28 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | hexanol | 102.18 | 0.9997 | 0.9997 | 0.9995 | 0.9993 | 0.9990 | 0.9988 | 0.9988 | 0.9988 | 0.9989 | 0.9991 | 0.9994 | 0.9997 |
| | 2-ethylhexanol | 130.2 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| Benzene/Toluene | Benzene | 78.11 | 0.9837 | 0.9823 | 0.9792 | 0.9759 | 0.9710 | 0.9667 | 0.9649 | 0.9649 | 0.9677 | 0.9731 | 0.9787 | 0.9828 |
| | Toluene | 92.13 | 0.9957 | 0.9953 | 0.9942 | 0.9930 | 0.9913 | 0.9900 | 0.9894 | 0.9894 | 0.9903 | 0.9921 | 0.9940 | 0.9954 |
| Carboxylic Acids | acetic acid | 60.05 | 0.9975 | 0.9973 | 0.9968 | 0.9959 | 0.9950 | 0.9943 | 0.9940 | 0.9940 | 0.9944 | 0.9954 | 0.9966 | 0.9973 |
| | propionic acid | 74.08 | 0.9992 | 0.9991 | 0.9990 | 0.9988 | 0.9986 | 0.9984 | 0.9982 | 0.9982 | 0.9985 | 0.9987 | 0.9989 | 0.9992 |
| | butyric acid | 88.12 | 1.0000 | 0.9999 | 0.9999 | 0.9998 | 0.9997 | 0.9996 | 0.9995 | 0.9995 | 0.9996 | 0.9997 | 0.9999 | 0.9999 |
| Chemical Products NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Chemical Additives | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Crude Petroleum | crude oil | 50 | 0.9857 | 0.9849 | 0.9830 | 0.9811 | 0.9788 | 0.9769 | 0.9760 | 0.9760 | 0.9773 | 0.9798 | 0.9827 | 0.9852 |
| | crude oil RVP 5 | 50 | 0.9603 | 0.9581 | 0.9530 | 0.9479 | 0.9419 | 0.9368 | 0.9346 | 0.9346 | 0.9380 | 0.9444 | 0.9522 | 0.9588 |
| Distillate Fuel Oils | #1 diesel | 180 | 0.9996 | 0.9996 | 0.9995 | 0.9994 | 0.9992 | 0.9991 | 0.9990 | 0.9990 | 0.9991 | 0.9993 | 0.9994 | 0.9996 |
| | #2 diesel | 130 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 |
| | marine diesel oil | 130 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 |
| | gas oil | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Gasoline | Gasoline RVP 6 | 68 | 0.9555 | 0.9531 | 0.9473 | 0.9413 | 0.9339 | 0.9281 | 0.9257 | 0.9257 | 0.9294 | 0.9371 | 0.9463 | 0.9539 |
| | Gasoline RVP 7 | 68 | 0.9507 | 0.9481 | 0.9416 | 0.9348 | 0.9261 | 0.9196 | 0.9169 | 0.9169 | 0.9209 | 0.9298 | 0.9405 | 0.9490 |
| | Gasoline RVP 7.8 | 68 | 0.9452 | 0.9421 | 0.9351 | 0.9278 | 0.9183 | 0.9110 | 0.9080 | 0.9080 | 0.9126 | 0.9224 | 0.9339 | 0.9432 |
| | Gasoline RVP 8.3 | 68 | 0.9415 | 0.9382 | 0.9308 | 0.9232 | 0.9132 | 0.9056 | 0.9024 | 0.9024 | 0.9072 | 0.9175 | 0.9296 | 0.9393 |
| | Gasoline RVP 10 | 66 | 0.9291 | 0.9250 | 0.9169 | 0.9087 | 0.8978 | 0.8894 | 0.8859 | 0.8859 | 0.8912 | 0.9024 | 0.9156 | 0.9264 |
| | Gasoline RVP 11.5 | 65 | 0.9177 | 0.9134 | 0.9038 | 0.8940 | 0.8814 | 0.8718 | 0.8678 | 0.8678 | 0.8738 | 0.8867 | 0.9022 | 0.9148 |

| | | | Galveston - Loaded | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 515.8 | 518 | 524.1 | 530 | 536.9 | 542.2 | 544.3 | 544.4 | 541.1 | 534.1 | 525.4 | 518.1 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | | **Δ Tv** | 4.82 | 5.58 | 6.00 | 6.18 | 6.50 | 6.72 | 6.65 | 6.64 | 6.51 | 6.31 | 5.40 | 4.83 |
| | | **Tla** | 516.69 | 519.11 | 525.40 | 531.42 | 538.47 | 543.84 | 545.91 | 545.97 | 542.57 | 535.47 | 526.47 | 518.97 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 2 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Gasoline RVP 13 | 62 | 0.9074 | 0.9027 | 0.8922 | 0.8814 | 0.8678 | 0.8576 | 0.8534 | 0.8534 | 0.8597 | 0.8736 | 0.8904 | 0.9042 |
| Kerosene | kerosene (Fuel Oil #1) | 170 | 0.9996 | 0.9995 | 0.9995 | 0.9994 | 0.9992 | 0.9991 | 0.9990 | 0.9990 | 0.9991 | 0.9993 | 0.9995 | 0.9996 |
| | jet kerosene (Jet A) | 130 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9998 | 0.9998 | 0.9999 |
| | jet naphtha (JP-4) | 80 | 0.9816 | 0.9802 | 0.9775 | 0.9747 | 0.9716 | 0.9684 | 0.9669 | 0.9669 | 0.9692 | 0.9729 | 0.9770 | 0.9807 |
| Naphtha and Solvents | Naphtha | 110 | 0.9973 | 0.9971 | 0.9969 | 0.9967 | 0.9965 | 0.9963 | 0.9963 | 0.9963 | 0.9964 | 0.9966 | 0.9969 | 0.9972 |
| | Coker gas | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Cat Gas | 80 | 0.9816 | 0.9802 | 0.9775 | 0.9747 | 0.9716 | 0.9684 | 0.9669 | 0.9669 | 0.9692 | 0.9729 | 0.9770 | 0.9807 |
| | Alkylates | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organic Compounds NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Other Hydrocarbons | Styrene | 104.14 | 0.9987 | 0.9986 | 0.9984 | 0.9980 | 0.9975 | 0.9972 | 0.9971 | 0.9971 | 0.9973 | 0.9977 | 0.9983 | 0.9986 |
| | Cumene | 120.2 | 0.9991 | 0.9991 | 0.9989 | 0.9987 | 0.9985 | 0.9982 | 0.9981 | 0.9981 | 0.9983 | 0.9986 | 0.9989 | 0.9991 |
| | MEK | 72.1 | 0.9830 | 0.9817 | 0.9791 | 0.9760 | 0.9699 | 0.9655 | 0.9637 | 0.9637 | 0.9664 | 0.9725 | 0.9786 | 0.9821 |
| | MTBE | 88.15 | 0.9441 | 0.9402 | 0.9344 | 0.9277 | 0.9128 | 0.9029 | 0.8991 | 0.8991 | 0.9048 | 0.9191 | 0.9335 | 0.9415 |
| | Butyl Acrylate | 128.17 | 0.9990 | 0.9989 | 0.9987 | 0.9986 | 0.9982 | 0.9979 | 0.9977 | 0.9977 | 0.9979 | 0.9984 | 0.9987 | 0.9989 |
| | Vinyl Acetate | 86.09 | 0.9817 | 0.9803 | 0.9766 | 0.9726 | 0.9669 | 0.9615 | 0.9590 | 0.9590 | 0.9628 | 0.9693 | 0.9759 | 0.9808 |
| | Xylene | 106.17 | 0.9986 | 0.9986 | 0.9982 | 0.9978 | 0.9973 | 0.9969 | 0.9967 | 0.9967 | 0.9970 | 0.9975 | 0.9982 | 0.9986 |
| | Propyl Acetate | 102.13 | 0.9947 | 0.9942 | 0.9928 | 0.9912 | 0.9894 | 0.9881 | 0.9874 | 0.9874 | 0.9884 | 0.9902 | 0.9926 | 0.9943 |
| | MIBK | 100.16 | 0.9988 | 0.9987 | 0.9985 | 0.9981 | 0.9976 | 0.9972 | 0.9970 | 0.9970 | 0.9973 | 0.9978 | 0.9985 | 0.9988 |
| Petroleum Products NEC | Lube oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Light and Heavy Cycle Oils | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Residual Fuel Oil | Residual Fuel | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| | Marine Residual Fuel | 190 | 0.9996 | 0.9996 | 0.9995 | 0.9993 | 0.9991 | 0.9989 | 0.9988 | 0.9988 | 0.9990 | 0.9992 | 0.9994 | 0.9996 |
| | No. 6 Fuel Oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| | | | Port Arthur - Loaded | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 512.2 | 515.6 | 522.2 | 528.2 | 535.4 | 540.9 | 542.7 | 542.5 | 538.7 | 530.1 | 520.9 | 514.2 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | | **Δ Tv** | 2.84 | 3.20 | 3.46 | 3.57 | 3.71 | 3.78 | 3.79 | 3.80 | 3.71 | 3.77 | 3.26 | 2.90 |
| | | **Tla** | 512.64 | 516.16 | 522.85 | 528.91 | 536.18 | 541.72 | 543.51 | 543.28 | 539.44 | 530.79 | 521.43 | 514.63 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 1 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 100.2 | 0.9932 | 0.9923 | 0.9909 | 0.9891 | 0.9863 | 0.9844 | 0.9836 | 0.9836 | 0.9852 | 0.9884 | 0.9912 | 0.9927 |
| | n-decane | 142.29 | 0.9998 | 0.9998 | 0.9997 | 0.9995 | 0.9993 | 0.9992 | 0.9991 | 0.9991 | 0.9992 | 0.9995 | 0.9997 | 0.9998 |
| | 1-heptene | 98.19 | 0.9926 | 0.9916 | 0.9901 | 0.9886 | 0.9858 | 0.9838 | 0.9831 | 0.9831 | 0.9846 | 0.9880 | 0.9903 | 0.9921 |
| | hexane | 86.17 | 0.9762 | 0.9736 | 0.9694 | 0.9644 | 0.9573 | 0.9524 | 0.9500 | 0.9500 | 0.9546 | 0.9627 | 0.9702 | 0.9749 |
| | nonene | 126.24 | 0.9979 | 0.9978 | 0.9977 | 0.9977 | 0.9975 | 0.9975 | 0.9974 | 0.9974 | 0.9975 | 0.9976 | 0.9978 | 0.9979 |
| Alcohols | methanol | 32.04 | 0.9830 | 0.9805 | 0.9764 | 0.9715 | 0.9640 | 0.9589 | 0.9564 | 0.9564 | 0.9611 | 0.9699 | 0.9772 | 0.9818 |
| | ethanol | 46.07 | 0.9929 | 0.9916 | 0.9895 | 0.9871 | 0.9831 | 0.9803 | 0.9789 | 0.9789 | 0.9815 | 0.9864 | 0.9899 | 0.9923 |
| | isopropanol | 60.09 | 0.9943 | 0.9933 | 0.9918 | 0.9900 | 0.9870 | 0.9849 | 0.9838 | 0.9838 | 0.9858 | 0.9894 | 0.9921 | 0.9938 |
| | butanols (iso Butyl Alcohol) | 74.12 | 0.9983 | 0.9981 | 0.9977 | 0.9971 | 0.9962 | 0.9955 | 0.9952 | 0.9952 | 0.9958 | 0.9969 | 0.9978 | 0.9982 |
| | decanol | 158.28 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | hexanol | 102.18 | 0.9998 | 0.9997 | 0.9996 | 0.9994 | 0.9991 | 0.9989 | 0.9988 | 0.9988 | 0.9990 | 0.9993 | 0.9996 | 0.9998 |
| | 2-ethylhexanol | 130.2 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| Benzene/Toluene | Benzene | 78.11 | 0.9855 | 0.9837 | 0.9808 | 0.9776 | 0.9724 | 0.9686 | 0.9667 | 0.9667 | 0.9703 | 0.9766 | 0.9814 | 0.9846 |
| | Toluene | 92.13 | 0.9963 | 0.9957 | 0.9947 | 0.9937 | 0.9918 | 0.9906 | 0.9900 | 0.9900 | 0.9911 | 0.9933 | 0.9949 | 0.9960 |
| Carboxylic Acids | acetic acid | 60.05 | 0.9978 | 0.9975 | 0.9970 | 0.9963 | 0.9953 | 0.9946 | 0.9943 | 0.9943 | 0.9948 | 0.9961 | 0.9971 | 0.9976 |
| | propionic acid | 74.08 | 0.9993 | 0.9992 | 0.9991 | 0.9989 | 0.9986 | 0.9985 | 0.9984 | 0.9984 | 0.9986 | 0.9988 | 0.9991 | 0.9993 |
| | butyric acid | 88.12 | 1.0000 | 1.0000 | 0.9999 | 0.9998 | 0.9997 | 0.9996 | 0.9996 | 0.9996 | 0.9997 | 0.9998 | 0.9999 | 1.0000 |
| Chemical Products NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Chemical Additives | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Crude Petroleum | crude oil | 50 | 0.9868 | 0.9857 | 0.9840 | 0.9820 | 0.9795 | 0.9777 | 0.9769 | 0.9769 | 0.9785 | 0.9814 | 0.9843 | 0.9862 |
| | crude oil RVP 5 | 50 | 0.9632 | 0.9603 | 0.9556 | 0.9504 | 0.9436 | 0.9391 | 0.9368 | 0.9368 | 0.9410 | 0.9487 | 0.9565 | 0.9618 |
| Distillate Fuel Oils | #1 diesel | 180 | 0.9997 | 0.9996 | 0.9995 | 0.9994 | 0.9992 | 0.9991 | 0.9991 | 0.9991 | 0.9992 | 0.9994 | 0.9995 | 0.9996 |
| | #2 diesel | 130 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| | marine diesel oil | 130 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| | gas oil | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Gasoline | Gasoline RVP 6 | 68 | 0.9587 | 0.9555 | 0.9503 | 0.9443 | 0.9360 | 0.9306 | 0.9281 | 0.9281 | 0.9329 | 0.9423 | 0.9513 | 0.9571 |
| | Gasoline RVP 7 | 68 | 0.9542 | 0.9507 | 0.9450 | 0.9382 | 0.9285 | 0.9223 | 0.9196 | 0.9196 | 0.9249 | 0.9360 | 0.9461 | 0.9524 |
| | Gasoline RVP 7.8 | 68 | 0.9494 | 0.9452 | 0.9387 | 0.9315 | 0.9210 | 0.9141 | 0.9110 | 0.9110 | 0.9170 | 0.9292 | 0.9399 | 0.9473 |
| | Gasoline RVP 8.3 | 68 | 0.9459 | 0.9415 | 0.9346 | 0.9271 | 0.9160 | 0.9088 | 0.9056 | 0.9056 | 0.9118 | 0.9246 | 0.9359 | 0.9437 |
| | Gasoline RVP 10 | 66 | 0.9346 | 0.9291 | 0.9209 | 0.9129 | 0.9009 | 0.8929 | 0.8894 | 0.8894 | 0.8963 | 0.9103 | 0.9223 | 0.9318 |
| | Gasoline RVP 11.5 | 65 | 0.9235 | 0.9177 | 0.9087 | 0.8990 | 0.8850 | 0.8758 | 0.8718 | 0.8718 | 0.8796 | 0.8958 | 0.9104 | 0.9206 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Port Arthur - Loaded** | | | | | | | | | | | |
| | | **Min. Liq. Temp** | 512.2 | 515.6 | 522.2 | 528.2 | 535.4 | 540.9 | 542.7 | 542.5 | 538.7 | 530.1 | 520.9 | 514.2 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | | **Δ Tv** | 2.84 | 3.20 | 3.46 | 3.57 | 3.71 | 3.78 | 3.79 | 3.80 | 3.71 | 3.77 | 3.26 | 2.90 |
| | | **Tla** | 512.64 | 516.16 | 522.85 | 528.91 | 536.18 | 541.72 | 543.51 | 543.28 | 539.44 | 530.79 | 521.43 | 514.63 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 1 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Gasoline RVP 13 | 62 | 0.9137 | 0.9074 | 0.8975 | 0.8869 | 0.8717 | 0.8619 | 0.8576 | 0.8576 | 0.8659 | 0.8834 | 0.8993 | 0.9105 |
| Kerosene | kerosene (Fuel Oil #1) | 170 | 0.9996 | 0.9996 | 0.9995 | 0.9994 | 0.9993 | 0.9991 | 0.9991 | 0.9991 | 0.9992 | 0.9994 | 0.9995 | 0.9996 |
| | jet kerosene (Jet A) | 130 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9998 | 0.9998 | 0.9999 | 0.9999 |
| | jet naphtha (JP-4) | 80 | 0.9834 | 0.9816 | 0.9788 | 0.9761 | 0.9725 | 0.9699 | 0.9684 | 0.9684 | 0.9711 | 0.9752 | 0.9793 | 0.9825 |
| Naphtha and Solvents | Naphtha | 110 | 0.9974 | 0.9973 | 0.9970 | 0.9968 | 0.9966 | 0.9964 | 0.9963 | 0.9963 | 0.9965 | 0.9968 | 0.9971 | 0.9973 |
| | Coker gas | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Cat Gas | 80 | 0.9834 | 0.9816 | 0.9788 | 0.9761 | 0.9725 | 0.9699 | 0.9684 | 0.9684 | 0.9711 | 0.9752 | 0.9793 | 0.9825 |
| | Alkylates | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organic Compounds NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Other Hydrocarbons | Styrene | 104.14 | 0.9988 | 0.9987 | 0.9985 | 0.9982 | 0.9977 | 0.9973 | 0.9972 | 0.9972 | 0.9975 | 0.9981 | 0.9985 | 0.9987 |
| | Cumene | 120.2 | 0.9993 | 0.9991 | 0.9990 | 0.9988 | 0.9986 | 0.9984 | 0.9982 | 0.9982 | 0.9985 | 0.9987 | 0.9990 | 0.9992 |
| | MEK | 72.1 | 0.9846 | 0.9830 | 0.9804 | 0.9778 | 0.9716 | 0.9673 | 0.9655 | 0.9655 | 0.9690 | 0.9769 | 0.9808 | 0.9838 |
| | MTBE | 88.15 | 0.9492 | 0.9441 | 0.9371 | 0.9317 | 0.9170 | 0.9067 | 0.9029 | 0.9029 | 0.9107 | 0.9299 | 0.9380 | 0.9466 |
| | Butyl Acrylate | 128.17 | 0.9991 | 0.9990 | 0.9988 | 0.9986 | 0.9984 | 0.9980 | 0.9979 | 0.9979 | 0.9981 | 0.9986 | 0.9988 | 0.9990 |
| | Vinyl Acetate | 86.09 | 0.9836 | 0.9817 | 0.9785 | 0.9746 | 0.9685 | 0.9640 | 0.9615 | 0.9615 | 0.9661 | 0.9734 | 0.9792 | 0.9827 |
| | Xylene | 106.17 | 0.9988 | 0.9986 | 0.9985 | 0.9980 | 0.9974 | 0.9971 | 0.9969 | 0.9969 | 0.9972 | 0.9979 | 0.9985 | 0.9987 |
| | Propyl Acetate | 102.13 | 0.9953 | 0.9947 | 0.9936 | 0.9920 | 0.9899 | 0.9886 | 0.9881 | 0.9881 | 0.9892 | 0.9915 | 0.9939 | 0.9950 |
| | MIBK | 100.16 | 0.9990 | 0.9988 | 0.9986 | 0.9984 | 0.9977 | 0.9973 | 0.9972 | 0.9972 | 0.9975 | 0.9982 | 0.9987 | 0.9989 |
| Petroleum Products NEC | Lube oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Light and Heavy Cycle Oils | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Residual Fuel Oil | Residual Fuel | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 | 0.9999 |
| | Marine Residual Fuel | 190 | 0.9997 | 0.9996 | 0.9995 | 0.9994 | 0.9992 | 0.9990 | 0.9989 | 0.9989 | 0.9991 | 0.9994 | 0.9996 | 0.9996 |
| | No. 6 Fuel Oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| | | | Corpus Christi - Loaded | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 516.1 | 519.5 | 526 | 531.5 | 537.5 | 541.9 | 543.8 | 543.9 | 540.8 | 533.8 | 525.1 | 518.1 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | | **Δ Tv** | 33.59 | 39.38 | 44.90 | 48.60 | 51.77 | 57.11 | 60.60 | 56.48 | 49.50 | 44.60 | 36.50 | 32.52 |
| | | **Tla** | 521.56 | 526.47 | 534.69 | 541.48 | 548.84 | 554.62 | 557.08 | 556.00 | 551.05 | 542.40 | 531.44 | 523.23 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 5 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 100.2 | 0.9912 | 0.9897 | 0.9870 | 0.9844 | 0.9815 | 0.9786 | 0.9770 | 0.9780 | 0.9802 | 0.9840 | 0.9881 | 0.9906 |
| | n-decane | 142.29 | 0.9997 | 0.9996 | 0.9994 | 0.9992 | 0.9990 | 0.9988 | 0.9988 | 0.9988 | 0.9989 | 0.9992 | 0.9995 | 0.9997 |
| | 1-heptene | 98.19 | 0.9903 | 0.9891 | 0.9866 | 0.9838 | 0.9807 | 0.9772 | 0.9755 | 0.9767 | 0.9790 | 0.9834 | 0.9879 | 0.9898 |
| | hexane | 86.17 | 0.9702 | 0.9660 | 0.9591 | 0.9524 | 0.9439 | 0.9360 | 0.9319 | 0.9346 | 0.9401 | 0.9512 | 0.9618 | 0.9685 |
| | nonene | 126.24 | 0.9978 | 0.9977 | 0.9976 | 0.9975 | 0.9973 | 0.9973 | 0.9972 | 0.9972 | 0.9973 | 0.9974 | 0.9976 | 0.9977 |
| Alcohols | methanol | 32.04 | 0.9772 | 0.9731 | 0.9660 | 0.9589 | 0.9503 | 0.9418 | 0.9373 | 0.9403 | 0.9463 | 0.9577 | 0.9689 | 0.9756 |
| | ethanol | 46.07 | 0.9899 | 0.9879 | 0.9842 | 0.9803 | 0.9754 | 0.9701 | 0.9673 | 0.9692 | 0.9730 | 0.9796 | 0.9858 | 0.9891 |
| | isopropanol | 60.09 | 0.9921 | 0.9906 | 0.9878 | 0.9849 | 0.9809 | 0.9769 | 0.9747 | 0.9761 | 0.9791 | 0.9843 | 0.9890 | 0.9915 |
| | butanols (iso Butyl Alcohol) | 74.12 | 0.9978 | 0.9973 | 0.9964 | 0.9955 | 0.9942 | 0.9929 | 0.9922 | 0.9927 | 0.9936 | 0.9953 | 0.9968 | 0.9976 |
| | decanol | 158.28 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | hexanol | 102.18 | 0.9996 | 0.9994 | 0.9992 | 0.9989 | 0.9987 | 0.9985 | 0.9983 | 0.9985 | 0.9986 | 0.9989 | 0.9993 | 0.9995 |
| | 2-ethylhexanol | 130.2 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9997 | 0.9998 | 0.9998 | 0.9999 | 0.9999 |
| Benzene/Toluene | Benzene | 78.11 | 0.9814 | 0.9787 | 0.9738 | 0.9686 | 0.9620 | 0.9562 | 0.9533 | 0.9552 | 0.9592 | 0.9677 | 0.9759 | 0.9803 |
| | Toluene | 92.13 | 0.9949 | 0.9940 | 0.9923 | 0.9906 | 0.9885 | 0.9864 | 0.9853 | 0.9861 | 0.9875 | 0.9903 | 0.9930 | 0.9946 |
| Carboxylic Acids | acetic acid | 60.05 | 0.9971 | 0.9966 | 0.9955 | 0.9946 | 0.9934 | 0.9918 | 0.9911 | 0.9916 | 0.9926 | 0.9944 | 0.9959 | 0.9969 |
| | propionic acid | 74.08 | 0.9991 | 0.9989 | 0.9987 | 0.9985 | 0.9980 | 0.9976 | 0.9974 | 0.9975 | 0.9978 | 0.9985 | 0.9988 | 0.9990 |
| | butyric acid | 88.12 | 0.9999 | 0.9999 | 0.9997 | 0.9996 | 0.9994 | 0.9992 | 0.9992 | 0.9992 | 0.9993 | 0.9996 | 0.9998 | 0.9999 |
| Chemical Products NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Chemical Additives | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Crude Petroleum | crude oil | 50 | 0.9843 | 0.9827 | 0.9801 | 0.9777 | 0.9748 | 0.9720 | 0.9706 | 0.9715 | 0.9734 | 0.9773 | 0.9811 | 0.9836 |
| | crude oil RVP 5 | 50 | 0.9565 | 0.9522 | 0.9453 | 0.9391 | 0.9313 | 0.9242 | 0.9205 | 0.9230 | 0.9279 | 0.9380 | 0.9479 | 0.9548 |
| Distillate Fuel Oils | #1 diesel | 180 | 0.9995 | 0.9994 | 0.9993 | 0.9991 | 0.9989 | 0.9987 | 0.9986 | 0.9987 | 0.9988 | 0.9991 | 0.9994 | 0.9995 |
| | #2 diesel | 130 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9998 | 0.9999 | 0.9999 |
| | marine diesel oil | 130 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9998 | 0.9999 | 0.9999 |
| | gas oil | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Gasoline | Gasoline RVP 6 | 68 | 0.9513 | 0.9463 | 0.9381 | 0.9306 | 0.9220 | 0.9140 | 0.9098 | 0.9126 | 0.9182 | 0.9294 | 0.9413 | 0.9493 |
| | Gasoline RVP 7 | 68 | 0.9461 | 0.9405 | 0.9310 | 0.9223 | 0.9129 | 0.9040 | 0.8993 | 0.9024 | 0.9087 | 0.9209 | 0.9348 | 0.9439 |
| | Gasoline RVP 7.8 | 68 | 0.9399 | 0.9339 | 0.9237 | 0.9141 | 0.9034 | 0.8936 | 0.8885 | 0.8919 | 0.8987 | 0.9126 | 0.9278 | 0.9375 |
| | Gasoline RVP 8.3 | 68 | 0.9359 | 0.9296 | 0.9189 | 0.9088 | 0.8976 | 0.8873 | 0.8821 | 0.8856 | 0.8927 | 0.9072 | 0.9232 | 0.9333 |
| | Gasoline RVP 10 | 66 | 0.9223 | 0.9156 | 0.9040 | 0.8929 | 0.8807 | 0.8690 | 0.8629 | 0.8670 | 0.8752 | 0.8912 | 0.9087 | 0.9196 |
| | Gasoline RVP 11.5 | 65 | 0.9104 | 0.9022 | 0.8885 | 0.8758 | 0.8619 | 0.8493 | 0.8428 | 0.8471 | 0.8558 | 0.8738 | 0.8940 | 0.9071 |

| | | | Corpus Christi - Loaded | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 516.1 | 519.5 | 526 | 531.5 | 537.5 | 541.9 | 543.8 | 543.9 | 540.8 | 533.8 | 525.1 | 518.1 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | | **Δ Tv** | 33.59 | 39.38 | 44.90 | 48.60 | 51.77 | 57.11 | 60.60 | 56.48 | 49.50 | 44.60 | 36.50 | 32.52 |
| | | **Tla** | 521.56 | 526.47 | 534.69 | 541.48 | 548.84 | 554.62 | 557.08 | 556.00 | 551.05 | 542.40 | 531.44 | 523.23 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 5 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Gasoline RVP 13 | 62 | 0.8993 | 0.8904 | 0.8755 | 0.8619 | 0.8472 | 0.8338 | 0.8269 | 0.8314 | 0.8408 | 0.8597 | 0.8814 | 0.8957 |
| Kerosene | kerosene (Fuel Oil #1) | 170 | 0.9995 | 0.9995 | 0.9993 | 0.9991 | 0.9989 | 0.9987 | 0.9985 | 0.9986 | 0.9988 | 0.9991 | 0.9994 | 0.9995 |
| | jet kerosene (Jet A) | 130 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9997 | 0.9996 | 0.9996 | 0.9996 | 0.9997 | 0.9997 | 0.9998 | 0.9999 |
| | jet naphtha (JP-4) | 80 | 0.9793 | 0.9770 | 0.9734 | 0.9699 | 0.9647 | 0.9615 | 0.9602 | 0.9610 | 0.9628 | 0.9692 | 0.9747 | 0.9784 |
| Naphtha and Solvents | Naphtha | 110 | 0.9971 | 0.9969 | 0.9966 | 0.9964 | 0.9962 | 0.9960 | 0.9959 | 0.9959 | 0.9961 | 0.9964 | 0.9967 | 0.9970 |
| | Coker gas | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Cat Gas | 80 | 0.9793 | 0.9770 | 0.9734 | 0.9699 | 0.9647 | 0.9615 | 0.9602 | 0.9610 | 0.9628 | 0.9692 | 0.9747 | 0.9784 |
| | Alkylates | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organic Compounds NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Other Hydrocarbons | Styrene | 104.14 | 0.9985 | 0.9983 | 0.9978 | 0.9973 | 0.9968 | 0.9961 | 0.9957 | 0.9960 | 0.9964 | 0.9973 | 0.9980 | 0.9985 |
| | Cumene | 120.2 | 0.9990 | 0.9989 | 0.9986 | 0.9984 | 0.9979 | 0.9974 | 0.9972 | 0.9974 | 0.9977 | 0.9983 | 0.9987 | 0.9989 |
| | MEK | 72.1 | 0.9808 | 0.9786 | 0.9734 | 0.9673 | 0.9611 | 0.9554 | 0.9524 | 0.9544 | 0.9583 | 0.9664 | 0.9760 | 0.9800 |
| | MTBE | 88.15 | 0.9380 | 0.9335 | 0.9213 | 0.9067 | 0.8935 | 0.8824 | 0.8770 | 0.8806 | 0.8879 | 0.9048 | 0.9277 | 0.9362 |
| | Butyl Acrylate | 128.17 | 0.9988 | 0.9987 | 0.9985 | 0.9980 | 0.9975 | 0.9971 | 0.9968 | 0.9970 | 0.9973 | 0.9979 | 0.9986 | 0.9988 |
| | Vinyl Acetate | 86.09 | 0.9792 | 0.9759 | 0.9701 | 0.9640 | 0.9553 | 0.9476 | 0.9437 | 0.9463 | 0.9515 | 0.9628 | 0.9726 | 0.9779 |
| | Xylene | 106.17 | 0.9985 | 0.9982 | 0.9976 | 0.9971 | 0.9963 | 0.9955 | 0.9951 | 0.9953 | 0.9959 | 0.9970 | 0.9978 | 0.9984 |
| | Propyl Acetate | 102.13 | 0.9939 | 0.9926 | 0.9905 | 0.9886 | 0.9862 | 0.9838 | 0.9826 | 0.9834 | 0.9850 | 0.9884 | 0.9912 | 0.9934 |
| | MIBK | 100.16 | 0.9987 | 0.9985 | 0.9979 | 0.9973 | 0.9966 | 0.9957 | 0.9952 | 0.9955 | 0.9961 | 0.9973 | 0.9981 | 0.9986 |
| Petroleum Products NEC | Lube oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Light and Heavy Cycle Oils | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Residual Fuel Oil | Residual Fuel | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9998 | 0.9998 | 0.9999 | 0.9999 |
| | Marine Residual Fuel | 190 | 0.9996 | 0.9994 | 0.9992 | 0.9990 | 0.9987 | 0.9984 | 0.9982 | 0.9983 | 0.9986 | 0.9990 | 0.9993 | 0.9995 |
| | No. 6 Fuel Oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

## *Empty*

**VENTED VAPOR SATURATION FACTOR ( Ks ) EMPTY BARGES**

Ks = 1 / ( 1 + 0.053 Pva Hvo )

where:

Ks = vented vapor saturation factor, dimensionless

Pva = vapor pressure at daily average liquid surface temperature, psia

Hvo = vapor space outage, ft

0.053 = constant, (psia-ft)-1

| |
|---|
| **10** |
| **0.053** |

| | | | **Houston - Empty** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 511.8 | 515.4 | 522.3 | 528.5 | 535.8 | 541.3 | 543.6 | 543.3 | 538.9 | 530.4 | 520.9 | 513.7 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | **Δ Tv** | **6.03** | **6.76** | **7.20** | **7.36** | **7.58** | **7.75** | **7.82** | **7.83** | **7.69** | **7.83** | **6.81** | **6.14** |
| | | **Tla** | **512.69** | **516.51** | **523.60** | **529.92** | **537.37** | **542.94** | **545.21** | **544.87** | **540.37** | **531.77** | **521.97** | **514.57** |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 2 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 100.2 | 0.8133 | 0.7948 | 0.7590 | 0.7250 | 0.6777 | 0.6488 | 0.6312 | 0.6370 | 0.6612 | 0.7133 | 0.7710 | 0.8040 |
| | n-decane | 142.29 | 0.9942 | 0.9925 | 0.9890 | 0.9838 | 0.9771 | 0.9729 | 0.9704 | 0.9712 | 0.9745 | 0.9821 | 0.9903 | 0.9933 |
| | 1-heptene | 98.19 | 0.8012 | 0.7797 | 0.7446 | 0.7170 | 0.6692 | 0.6405 | 0.6244 | 0.6297 | 0.6517 | 0.7093 | 0.7543 | 0.7903 |
| | hexane | 86.17 | 0.5514 | 0.5252 | 0.4800 | 0.4422 | 0.3967 | 0.3691 | 0.3515 | 0.3572 | 0.3818 | 0.4303 | 0.4941 | 0.5380 |
| | nonene | 126.24 | 0.9343 | 0.9326 | 0.9294 | 0.9268 | 0.9233 | 0.9211 | 0.9198 | 0.9202 | 0.9220 | 0.9259 | 0.9303 | 0.9334 |
| Alcohols | methanol | 32.04 | 0.6344 | 0.6016 | 0.5451 | 0.4984 | 0.4388 | 0.4043 | 0.3833 | 0.3901 | 0.4196 | 0.4831 | 0.5627 | 0.6176 |
| | ethanol | 46.07 | 0.8079 | 0.7795 | 0.7310 | 0.6907 | 0.6288 | 0.5901 | 0.5655 | 0.5734 | 0.6077 | 0.6759 | 0.7455 | 0.7934 |
| | isopropanol | 60.09 | 0.8398 | 0.8174 | 0.7771 | 0.7415 | 0.6887 | 0.6532 | 0.6292 | 0.6370 | 0.6703 | 0.7288 | 0.7897 | 0.8285 |
| | butanols (iso Butyl Alcohol) | 74.12 | 0.9475 | 0.9403 | 0.9253 | 0.9097 | 0.8840 | 0.8651 | 0.8515 | 0.8560 | 0.8744 | 0.9038 | 0.9306 | 0.9439 |
| | decanol | 158.28 | 1.0000 | 1.0000 | 1.0000 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 1.0000 | 1.0000 |
| | hexanol | 102.18 | 0.9932 | 0.9910 | 0.9844 | 0.9779 | 0.9693 | 0.9640 | 0.9609 | 0.9619 | 0.9661 | 0.9757 | 0.9866 | 0.9921 |
| | 2-ethylhexanol | 130.2 | 0.9980 | 0.9977 | 0.9971 | 0.9964 | 0.9953 | 0.9944 | 0.9938 | 0.9940 | 0.9949 | 0.9962 | 0.9973 | 0.9979 |
| Benzene/Toluene | Benzene | 78.11 | 0.6703 | 0.6438 | 0.5988 | 0.5615 | 0.5073 | 0.4733 | 0.4516 | 0.4586 | 0.4890 | 0.5483 | 0.6123 | 0.6568 |
| | Toluene | 92.13 | 0.8904 | 0.8746 | 0.8459 | 0.8203 | 0.7796 | 0.7531 | 0.7361 | 0.7417 | 0.7649 | 0.8107 | 0.8548 | 0.8824 |
| Carboxylic Acids | acetic acid | 60.05 | 0.9310 | 0.9223 | 0.9074 | 0.8874 | 0.8594 | 0.8427 | 0.8331 | 0.8363 | 0.8493 | 0.8802 | 0.9116 | 0.9266 |
| | propionic acid | 74.08 | 0.9785 | 0.9748 | 0.9684 | 0.9630 | 0.9558 | 0.9513 | 0.9447 | 0.9469 | 0.9531 | 0.9612 | 0.9702 | 0.9767 |
| | butyric acid | 88.12 | 0.9991 | 0.9987 | 0.9968 | 0.9940 | 0.9903 | 0.9862 | 0.9835 | 0.9844 | 0.9880 | 0.9931 | 0.9975 | 0.9990 |
| Chemical Products NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Chemical Additives | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Crude Petroleum | crude oil | 50 | 0.6914 | 0.6741 | 0.6434 | 0.6169 | 0.5847 | 0.5638 | 0.5500 | 0.5545 | 0.5734 | 0.6085 | 0.6528 | 0.6826 |
| | crude oil RVP 5 | 50 | 0.4401 | 0.4205 | 0.3877 | 0.3610 | 0.3306 | 0.3120 | 0.3001 | 0.3040 | 0.3205 | 0.3529 | 0.3975 | 0.4301 |
| Distillate Fuel Oils | #1 diesel | 180 | 0.9887 | 0.9869 | 0.9834 | 0.9800 | 0.9748 | 0.9711 | 0.9684 | 0.9693 | 0.9728 | 0.9788 | 0.9845 | 0.9878 |
| | #2 diesel | 130 | 0.9974 | 0.9970 | 0.9962 | 0.9954 | 0.9942 | 0.9933 | 0.9926 | 0.9928 | 0.9937 | 0.9951 | 0.9964 | 0.9972 |
| | marine diesel oil | 130 | 0.9974 | 0.9970 | 0.9962 | 0.9954 | 0.9942 | 0.9933 | 0.9926 | 0.9928 | 0.9937 | 0.9951 | 0.9964 | 0.9972 |

| | | | Houston - Empty | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 511.8 | 515.4 | 522.3 | 528.5 | 535.8 | 541.3 | 543.6 | 543.3 | 538.9 | 530.4 | 520.9 | 513.7 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | **Δ Tv** | **6.03** | **6.76** | **7.20** | **7.36** | **7.58** | **7.75** | **7.82** | **7.83** | **7.69** | **7.83** | **6.81** | **6.14** |
| | | **Tla** | **512.69** | **516.51** | **523.60** | **529.92** | **537.37** | **542.94** | **545.21** | **544.87** | **540.37** | **531.77** | **521.97** | **514.57** |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 2 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | gas oil | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Gasoline | Gasoline RVP 6 | 68 | 0.4105 | 0.3917 | 0.3596 | 0.3330 | 0.3013 | 0.2830 | 0.2720 | 0.2756 | 0.2909 | 0.3246 | 0.3695 | 0.4009 |
| | Gasoline RVP 7 | 68 | 0.3845 | 0.3666 | 0.3353 | 0.3090 | 0.2768 | 0.2589 | 0.2487 | 0.2520 | 0.2662 | 0.3006 | 0.3451 | 0.3753 |
| | Gasoline RVP 7.8 | 68 | 0.3600 | 0.3411 | 0.3103 | 0.2861 | 0.2557 | 0.2384 | 0.2284 | 0.2316 | 0.2457 | 0.2783 | 0.3193 | 0.3503 |
| | Gasoline RVP 8.3 | 68 | 0.3439 | 0.3256 | 0.2958 | 0.2725 | 0.2432 | 0.2267 | 0.2171 | 0.2202 | 0.2336 | 0.2650 | 0.3045 | 0.3345 |
| | Gasoline RVP 10 | 66 | 0.3001 | 0.2822 | 0.2554 | 0.2362 | 0.2114 | 0.1972 | 0.1889 | 0.1916 | 0.2032 | 0.2299 | 0.2625 | 0.2909 |
| | Gasoline RVP 11.5 | 65 | 0.2657 | 0.2506 | 0.2265 | 0.2079 | 0.1849 | 0.1720 | 0.1646 | 0.1670 | 0.1774 | 0.2019 | 0.2335 | 0.2580 |
| | Gasoline RVP 13 | 62 | 0.2411 | 0.2271 | 0.2049 | 0.1878 | 0.1669 | 0.1553 | 0.1487 | 0.1509 | 0.1601 | 0.1824 | 0.2114 | 0.2339 |
| Kerosene | kerosene (Fuel Oil #1) | 170 | 0.9883 | 0.9865 | 0.9834 | 0.9808 | 0.9755 | 0.9713 | 0.9682 | 0.9693 | 0.9734 | 0.9796 | 0.9843 | 0.9874 |
| | jet kerosene (Jet A) | 130 | 0.9966 | 0.9960 | 0.9951 | 0.9943 | 0.9927 | 0.9915 | 0.9906 | 0.9909 | 0.9921 | 0.9940 | 0.9954 | 0.9963 |
| | jet naphtha (JP-4) | 80 | 0.6403 | 0.6152 | 0.5758 | 0.5458 | 0.5104 | 0.4854 | 0.4674 | 0.4733 | 0.4983 | 0.5365 | 0.5865 | 0.6275 |
| Naphtha and Solvents | Naphtha | 110 | 0.9196 | 0.9158 | 0.9093 | 0.9038 | 0.8965 | 0.8920 | 0.8894 | 0.8903 | 0.8938 | 0.9019 | 0.9112 | 0.9177 |
| | Coker gas | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Cat Gas | 80 | 0.6403 | 0.6152 | 0.5758 | 0.5458 | 0.5104 | 0.4854 | 0.4674 | 0.4733 | 0.4983 | 0.5365 | 0.5865 | 0.6275 |
| | Alkylates | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organic Compounds NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Other Hydrocarbons | Styrene | 104.14 | 0.9612 | 0.9579 | 0.9521 | 0.9412 | 0.9257 | 0.9163 | 0.9107 | 0.9126 | 0.9200 | 0.9373 | 0.9537 | 0.9596 |
| | Cumene | 120.2 | 0.9759 | 0.9723 | 0.9661 | 0.9608 | 0.9538 | 0.9468 | 0.9402 | 0.9424 | 0.9513 | 0.9590 | 0.9679 | 0.9741 |
| | MEK | 72.1 | 0.6576 | 0.6337 | 0.5947 | 0.5638 | 0.4989 | 0.4629 | 0.4434 | 0.4497 | 0.4770 | 0.5495 | 0.6058 | 0.6455 |
| | MTBE | 88.15 | 0.3594 | 0.3361 | 0.3057 | 0.2875 | 0.2439 | 0.2219 | 0.2109 | 0.2145 | 0.2298 | 0.2781 | 0.3123 | 0.3473 |
| | Butyl Acrylate | 128.17 | 0.9705 | 0.9670 | 0.9608 | 0.9556 | 0.9457 | 0.9352 | 0.9290 | 0.9311 | 0.9394 | 0.9538 | 0.9625 | 0.9687 |
| | Vinyl Acetate | 86.09 | 0.6429 | 0.6168 | 0.5700 | 0.5292 | 0.4733 | 0.4369 | 0.4125 | 0.4203 | 0.4548 | 0.5153 | 0.5850 | 0.6296 |
| | Xylene | 106.17 | 0.9600 | 0.9565 | 0.9490 | 0.9358 | 0.9188 | 0.9085 | 0.8998 | 0.9034 | 0.9126 | 0.9315 | 0.9521 | 0.9583 |
| | Propyl Acetate | 102.13 | 0.8633 | 0.8481 | 0.8176 | 0.7834 | 0.7420 | 0.7183 | 0.7023 | 0.7093 | 0.7276 | 0.7726 | 0.8299 | 0.8556 |
| | MIBK | 100.16 | 0.9664 | 0.9623 | 0.9552 | 0.9462 | 0.9274 | 0.9160 | 0.9093 | 0.9115 | 0.9205 | 0.9414 | 0.9572 | 0.9643 |
| Petroleum Products NEC | Lube oil | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| | Light and Heavy Cycle Oils | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| Residual Fuel Oil | Residual Fuel | 190 | 0.9983 | 0.9981 | 0.9975 | 0.9969 | 0.9957 | 0.9948 | 0.9941 | 0.9943 | 0.9952 | 0.9966 | 0.9977 | 0.9982 |
| | Marine Residual Fuel | 190 | 0.9888 | 0.9875 | 0.9840 | 0.9799 | 0.9722 | 0.9666 | 0.9626 | 0.9639 | 0.9692 | 0.9782 | 0.9854 | 0.9881 |
| | No. 6 Fuel Oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.9999 | 0.9999 | 0.9999 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| | | | Galveston - Empty | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 515.8 | 518 | 524.1 | 530 | 536.9 | 542.2 | 544.3 | 544.4 | 541.1 | 534.1 | 525.4 | 518.1 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | **Δ Tv** | 4.82 | 5.58 | 6.00 | 6.18 | 6.50 | 6.72 | 6.65 | 6.64 | 6.51 | 6.31 | 5.40 | 4.83 |
| | | **Tla** | 516.69 | 519.11 | 525.40 | 531.42 | 538.47 | 543.84 | 545.91 | 545.97 | 542.57 | 535.47 | 526.47 | 518.97 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 2 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 100.2 | 0.7948 | 0.7815 | 0.7473 | 0.7133 | 0.6721 | 0.6428 | 0.6312 | 0.6312 | 0.6488 | 0.6892 | 0.7416 | 0.7859 |
| | n-decane | 142.29 | 0.9925 | 0.9912 | 0.9873 | 0.9821 | 0.9762 | 0.9720 | 0.9704 | 0.9704 | 0.9729 | 0.9787 | 0.9864 | 0.9916 |
| | 1-heptene | 98.19 | 0.7797 | 0.7643 | 0.7352 | 0.7093 | 0.6632 | 0.6350 | 0.6244 | 0.6244 | 0.6405 | 0.6814 | 0.7306 | 0.7693 |
| | hexane | 86.17 | 0.5252 | 0.5072 | 0.4667 | 0.4303 | 0.3916 | 0.3630 | 0.3515 | 0.3515 | 0.3691 | 0.4073 | 0.4603 | 0.5131 |
| | nonene | 126.24 | 0.9326 | 0.9312 | 0.9286 | 0.9259 | 0.9229 | 0.9207 | 0.9198 | 0.9198 | 0.9211 | 0.9242 | 0.9281 | 0.9317 |
| Alcohols | methanol | 32.04 | 0.6016 | 0.5791 | 0.5286 | 0.4831 | 0.4322 | 0.3970 | 0.3833 | 0.3833 | 0.4043 | 0.4527 | 0.5207 | 0.5864 |
| | ethanol | 46.07 | 0.7795 | 0.7594 | 0.7171 | 0.6759 | 0.6216 | 0.5816 | 0.5655 | 0.5655 | 0.5901 | 0.6438 | 0.7103 | 0.7660 |
| | isopropanol | 60.09 | 0.8174 | 0.8014 | 0.7649 | 0.7288 | 0.6825 | 0.6450 | 0.6292 | 0.6292 | 0.6532 | 0.7016 | 0.7589 | 0.8067 |
| | butanols (iso Butyl Alcohol) | 74.12 | 0.9403 | 0.9350 | 0.9200 | 0.9038 | 0.8808 | 0.8605 | 0.8515 | 0.8515 | 0.8651 | 0.8905 | 0.9174 | 0.9367 |
| | decanol | 158.28 | 1.0000 | 1.0000 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 1.0000 |
| | hexanol | 102.18 | 0.9910 | 0.9888 | 0.9822 | 0.9757 | 0.9682 | 0.9630 | 0.9609 | 0.9609 | 0.9640 | 0.9714 | 0.9811 | 0.9899 |
| | 2-ethylhexanol | 130.2 | 0.9977 | 0.9975 | 0.9969 | 0.9962 | 0.9951 | 0.9942 | 0.9938 | 0.9938 | 0.9944 | 0.9956 | 0.9968 | 0.9976 |
| Benzene/Toluene | Benzene | 78.11 | 0.6438 | 0.6252 | 0.5858 | 0.5483 | 0.5010 | 0.4659 | 0.4516 | 0.4516 | 0.4733 | 0.5202 | 0.5796 | 0.6313 |
| | Toluene | 92.13 | 0.8746 | 0.8630 | 0.8372 | 0.8107 | 0.7746 | 0.7473 | 0.7361 | 0.7361 | 0.7531 | 0.7897 | 0.8329 | 0.8669 |
| Carboxylic Acids | acetic acid | 60.05 | 0.9223 | 0.9158 | 0.9021 | 0.8802 | 0.8560 | 0.8395 | 0.8331 | 0.8331 | 0.8427 | 0.8662 | 0.8983 | 0.9180 |
| | propionic acid | 74.08 | 0.9748 | 0.9721 | 0.9666 | 0.9612 | 0.9549 | 0.9491 | 0.9447 | 0.9447 | 0.9513 | 0.9576 | 0.9657 | 0.9730 |
| | butyric acid | 88.12 | 0.9987 | 0.9980 | 0.9959 | 0.9931 | 0.9899 | 0.9853 | 0.9835 | 0.9835 | 0.9862 | 0.9912 | 0.9954 | 0.9982 |
| Chemical Products NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Chemical Additives | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Crude Petroleum | crude oil | 50 | 0.6741 | 0.6616 | 0.6343 | 0.6085 | 0.5809 | 0.5591 | 0.5500 | 0.5500 | 0.5638 | 0.5924 | 0.6299 | 0.6657 |
| | crude oil RVP 5 | 50 | 0.4205 | 0.4069 | 0.3784 | 0.3529 | 0.3272 | 0.3080 | 0.3001 | 0.3001 | 0.3120 | 0.3377 | 0.3739 | 0.4114 |
| Distillate Fuel Oils | #1 diesel | 180 | 0.9869 | 0.9855 | 0.9823 | 0.9788 | 0.9741 | 0.9702 | 0.9684 | 0.9684 | 0.9711 | 0.9761 | 0.9817 | 0.9860 |
| | #2 diesel | 130 | 0.9970 | 0.9967 | 0.9959 | 0.9951 | 0.9940 | 0.9931 | 0.9926 | 0.9926 | 0.9933 | 0.9945 | 0.9958 | 0.9968 |
| | marine diesel oil | 130 | 0.9970 | 0.9967 | 0.9959 | 0.9951 | 0.9940 | 0.9931 | 0.9926 | 0.9926 | 0.9933 | 0.9945 | 0.9958 | 0.9968 |
| | gas oil | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Gasoline | Gasoline RVP 6 | 68 | 0.3917 | 0.3787 | 0.3503 | 0.3246 | 0.2978 | 0.2792 | 0.2720 | 0.2720 | 0.2830 | 0.3087 | 0.3458 | 0.3830 |
| | Gasoline RVP 7 | 68 | 0.3666 | 0.3542 | 0.3261 | 0.3006 | 0.2732 | 0.2554 | 0.2487 | 0.2487 | 0.2589 | 0.2843 | 0.3216 | 0.3582 |
| | Gasoline RVP 7.8 | 68 | 0.3411 | 0.3281 | 0.3018 | 0.2783 | 0.2522 | 0.2350 | 0.2284 | 0.2284 | 0.2384 | 0.2628 | 0.2977 | 0.3323 |
| | Gasoline RVP 8.3 | 68 | 0.3256 | 0.3130 | 0.2876 | 0.2650 | 0.2399 | 0.2234 | 0.2171 | 0.2171 | 0.2267 | 0.2501 | 0.2837 | 0.3171 |
| | Gasoline RVP 10 | 66 | 0.2822 | 0.2701 | 0.2487 | 0.2299 | 0.2086 | 0.1944 | 0.1889 | 0.1889 | 0.1972 | 0.2172 | 0.2455 | 0.2740 |
| | Gasoline RVP 11.5 | 65 | 0.2506 | 0.2404 | 0.2200 | 0.2019 | 0.1823 | 0.1695 | 0.1646 | 0.1646 | 0.1720 | 0.1902 | 0.2168 | 0.2437 |

| | | | Galveston - Empty | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 515.8 | 518 | 524.1 | 530 | 536.9 | 542.2 | 544.3 | 544.4 | 541.1 | 534.1 | 525.4 | 518.1 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | **Δ Tv** | 4.82 | 5.58 | 6.00 | 6.18 | 6.50 | 6.72 | 6.65 | 6.64 | 6.51 | 6.31 | 5.40 | 4.83 |
| | | **Tla** | 516.69 | 519.11 | 525.40 | 531.42 | 538.47 | 543.84 | 545.91 | 545.97 | 542.57 | 535.47 | 526.47 | 518.97 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 2 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Gasoline RVP 13 | 62 | 0.2271 | 0.2177 | 0.1989 | 0.1824 | 0.1645 | 0.1531 | 0.1487 | 0.1487 | 0.1553 | 0.1717 | 0.1960 | 0.2208 |
| Kerosene | kerosene (Fuel Oil #1) | 170 | 0.9865 | 0.9852 | 0.9825 | 0.9796 | 0.9748 | 0.9703 | 0.9682 | 0.9682 | 0.9713 | 0.9768 | 0.9821 | 0.9856 |
| | jet kerosene (Jet A) | 130 | 0.9960 | 0.9956 | 0.9949 | 0.9940 | 0.9925 | 0.9912 | 0.9906 | 0.9906 | 0.9915 | 0.9932 | 0.9947 | 0.9958 |
| | jet naphtha (JP-4) | 80 | 0.6152 | 0.5977 | 0.5655 | 0.5365 | 0.5063 | 0.4793 | 0.4674 | 0.4674 | 0.4854 | 0.5188 | 0.5604 | 0.6034 |
| Naphtha and Solvents | Naphtha | 110 | 0.9158 | 0.9130 | 0.9074 | 0.9019 | 0.8956 | 0.8911 | 0.8894 | 0.8894 | 0.8920 | 0.8983 | 0.9065 | 0.9139 |
| | Coker gas | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Cat Gas | 80 | 0.6152 | 0.5977 | 0.5655 | 0.5365 | 0.5063 | 0.4793 | 0.4674 | 0.4674 | 0.4854 | 0.5188 | 0.5604 | 0.6034 |
| | Alkylates | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organic Compounds NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Other Hydrocarbons | Styrene | 104.14 | 0.9579 | 0.9554 | 0.9492 | 0.9373 | 0.9238 | 0.9144 | 0.9107 | 0.9107 | 0.9163 | 0.9295 | 0.9472 | 0.9562 |
| | Cumene | 120.2 | 0.9723 | 0.9696 | 0.9643 | 0.9590 | 0.9530 | 0.9446 | 0.9402 | 0.9402 | 0.9468 | 0.9556 | 0.9634 | 0.9705 |
| | MEK | 72.1 | 0.6337 | 0.6169 | 0.5840 | 0.5495 | 0.4914 | 0.4562 | 0.4434 | 0.4434 | 0.4629 | 0.5147 | 0.5788 | 0.6224 |
| | MTBE | 88.15 | 0.3361 | 0.3205 | 0.2994 | 0.2781 | 0.2390 | 0.2181 | 0.2109 | 0.2109 | 0.2219 | 0.2543 | 0.2963 | 0.3255 |
| | Butyl Acrylate | 128.17 | 0.9670 | 0.9643 | 0.9590 | 0.9538 | 0.9436 | 0.9331 | 0.9290 | 0.9290 | 0.9352 | 0.9500 | 0.9582 | 0.9652 |
| | Vinyl Acetate | 86.09 | 0.6168 | 0.5986 | 0.5557 | 0.5153 | 0.4670 | 0.4284 | 0.4125 | 0.4125 | 0.4369 | 0.4865 | 0.5488 | 0.6046 |
| | Xylene | 106.17 | 0.9565 | 0.9539 | 0.9446 | 0.9315 | 0.9167 | 0.9070 | 0.8998 | 0.8998 | 0.9085 | 0.9230 | 0.9424 | 0.9547 |
| | Propyl Acetate | 102.13 | 0.8481 | 0.8371 | 0.8059 | 0.7726 | 0.7372 | 0.7138 | 0.7023 | 0.7023 | 0.7183 | 0.7519 | 0.8001 | 0.8407 |
| | MIBK | 100.16 | 0.9623 | 0.9592 | 0.9532 | 0.9414 | 0.9251 | 0.9137 | 0.9093 | 0.9093 | 0.9160 | 0.9320 | 0.9522 | 0.9603 |
| Petroleum Products NEC | Lube oil | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| | Light and Heavy Cycle Oils | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| Residual Fuel Oil | Residual Fuel | 190 | 0.9981 | 0.9979 | 0.9973 | 0.9966 | 0.9955 | 0.9945 | 0.9941 | 0.9941 | 0.9948 | 0.9960 | 0.9972 | 0.9980 |
| | Marine Residual Fuel | 190 | 0.9875 | 0.9864 | 0.9826 | 0.9782 | 0.9712 | 0.9652 | 0.9626 | 0.9626 | 0.9666 | 0.9742 | 0.9820 | 0.9868 |
| | No. 6 Fuel Oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 1.0000 | 1.0000 | 1.0000 |

| | | | Port Arthur - Empty | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 512.2 | 515.6 | 522.2 | 528.2 | 535.4 | 540.9 | 542.7 | 542.5 | 538.7 | 530.1 | 520.9 | 514.2 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | **Δ Tv** | 2.84 | 3.20 | 3.46 | 3.57 | 3.71 | 3.78 | 3.79 | 3.80 | 3.71 | 3.77 | 3.26 | 2.90 |
| | | **Tla** | 512.64 | 516.16 | 522.85 | 528.91 | 536.18 | 541.72 | 543.51 | 543.28 | 539.44 | 530.79 | 521.43 | 514.63 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 1 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 100.2 | 0.8133 | 0.7948 | 0.7649 | 0.7305 | 0.6834 | 0.6549 | 0.6428 | 0.6428 | 0.6666 | 0.7197 | 0.7710 | 0.8040 |
| | n-decane | 142.29 | 0.9942 | 0.9925 | 0.9899 | 0.9847 | 0.9779 | 0.9737 | 0.9720 | 0.9720 | 0.9754 | 0.9830 | 0.9903 | 0.9933 |
| | 1-heptene | 98.19 | 0.8012 | 0.7797 | 0.7494 | 0.7215 | 0.6752 | 0.6460 | 0.6350 | 0.6350 | 0.6574 | 0.7126 | 0.7543 | 0.7903 |
| | hexane | 86.17 | 0.5514 | 0.5252 | 0.4869 | 0.4481 | 0.4019 | 0.3753 | 0.3630 | 0.3630 | 0.3866 | 0.4365 | 0.4941 | 0.5380 |
| | nonene | 126.24 | 0.9343 | 0.9326 | 0.9299 | 0.9272 | 0.9237 | 0.9215 | 0.9207 | 0.9207 | 0.9224 | 0.9264 | 0.9303 | 0.9334 |
| Alcohols | methanol | 32.04 | 0.6344 | 0.6016 | 0.5538 | 0.5056 | 0.4456 | 0.4118 | 0.3970 | 0.3970 | 0.4258 | 0.4914 | 0.5627 | 0.6176 |
| | ethanol | 46.07 | 0.8079 | 0.7795 | 0.7382 | 0.6971 | 0.6362 | 0.5988 | 0.5816 | 0.5816 | 0.6146 | 0.6844 | 0.7455 | 0.7934 |
| | isopropanol | 60.09 | 0.8398 | 0.8174 | 0.7834 | 0.7472 | 0.6951 | 0.6617 | 0.6450 | 0.6450 | 0.6763 | 0.7359 | 0.7897 | 0.8285 |
| | butanols (iso Butyl Alcohol) | 74.12 | 0.9475 | 0.9403 | 0.9279 | 0.9123 | 0.8872 | 0.8697 | 0.8605 | 0.8605 | 0.8776 | 0.9072 | 0.9306 | 0.9439 |
| | decanol | 158.28 | 1.0000 | 1.0000 | 1.0000 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 1.0000 | 1.0000 |
| | hexanol | 102.18 | 0.9932 | 0.9910 | 0.9855 | 0.9789 | 0.9704 | 0.9651 | 0.9630 | 0.9630 | 0.9672 | 0.9768 | 0.9866 | 0.9921 |
| | 2-ethylhexanol | 130.2 | 0.9980 | 0.9977 | 0.9972 | 0.9965 | 0.9954 | 0.9946 | 0.9942 | 0.9942 | 0.9950 | 0.9963 | 0.9973 | 0.9979 |
| Benzene/Toluene | Benzene | 78.11 | 0.6703 | 0.6438 | 0.6054 | 0.5674 | 0.5137 | 0.4810 | 0.4659 | 0.4659 | 0.4949 | 0.5558 | 0.6123 | 0.6568 |
| | Toluene | 92.13 | 0.8904 | 0.8746 | 0.8503 | 0.8244 | 0.7846 | 0.7589 | 0.7473 | 0.7473 | 0.7697 | 0.8162 | 0.8548 | 0.8824 |
| Carboxylic Acids | acetic acid | 60.05 | 0.9310 | 0.9223 | 0.9095 | 0.8910 | 0.8628 | 0.8460 | 0.8395 | 0.8395 | 0.8526 | 0.8838 | 0.9116 | 0.9266 |
| | propionic acid | 74.08 | 0.9785 | 0.9748 | 0.9693 | 0.9639 | 0.9567 | 0.9522 | 0.9491 | 0.9491 | 0.9540 | 0.9621 | 0.9702 | 0.9767 |
| | butyric acid | 88.12 | 0.9991 | 0.9987 | 0.9973 | 0.9945 | 0.9908 | 0.9871 | 0.9853 | 0.9853 | 0.9889 | 0.9935 | 0.9975 | 0.9990 |
| Chemical Products NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Chemical Additives | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Crude Petroleum | crude oil | 50 | 0.6914 | 0.6741 | 0.6481 | 0.6211 | 0.5885 | 0.5686 | 0.5591 | 0.5591 | 0.5771 | 0.6126 | 0.6528 | 0.6826 |
| | crude oil RVP 5 | 50 | 0.4401 | 0.4205 | 0.3925 | 0.3652 | 0.3341 | 0.3162 | 0.3080 | 0.3080 | 0.3238 | 0.3569 | 0.3975 | 0.4301 |
| Distillate Fuel Oils | #1 diesel | 180 | 0.9887 | 0.9869 | 0.9840 | 0.9806 | 0.9755 | 0.9719 | 0.9702 | 0.9702 | 0.9735 | 0.9795 | 0.9845 | 0.9878 |
| | #2 diesel | 130 | 0.9974 | 0.9970 | 0.9963 | 0.9955 | 0.9943 | 0.9935 | 0.9931 | 0.9931 | 0.9938 | 0.9953 | 0.9964 | 0.9972 |
| | marine diesel oil | 130 | 0.9974 | 0.9970 | 0.9963 | 0.9955 | 0.9943 | 0.9935 | 0.9931 | 0.9931 | 0.9938 | 0.9953 | 0.9964 | 0.9972 |
| | gas oil | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Gasoline | Gasoline RVP 6 | 68 | 0.4105 | 0.3917 | 0.3645 | 0.3371 | 0.3050 | 0.2869 | 0.2792 | 0.2792 | 0.2943 | 0.3289 | 0.3695 | 0.4009 |
| | Gasoline RVP 7 | 68 | 0.3845 | 0.3666 | 0.3402 | 0.3131 | 0.2805 | 0.2625 | 0.2554 | 0.2554 | 0.2697 | 0.3050 | 0.3451 | 0.3753 |
| | Gasoline RVP 7.8 | 68 | 0.3600 | 0.3411 | 0.3148 | 0.2899 | 0.2592 | 0.2420 | 0.2350 | 0.2350 | 0.2489 | 0.2825 | 0.3193 | 0.3503 |
| | Gasoline RVP 8.3 | 68 | 0.3439 | 0.3256 | 0.3001 | 0.2761 | 0.2466 | 0.2301 | 0.2234 | 0.2234 | 0.2367 | 0.2690 | 0.3045 | 0.3345 |
| | Gasoline RVP 10 | 66 | 0.3001 | 0.2822 | 0.2589 | 0.2392 | 0.2142 | 0.2002 | 0.1944 | 0.1944 | 0.2058 | 0.2333 | 0.2625 | 0.2909 |
| | Gasoline RVP 11.5 | 65 | 0.2657 | 0.2506 | 0.2300 | 0.2108 | 0.1875 | 0.1746 | 0.1695 | 0.1695 | 0.1798 | 0.2051 | 0.2335 | 0.2580 |

| | | | Port Arthur - Empty | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 512.2 | 515.6 | 522.2 | 528.2 | 535.4 | 540.9 | 542.7 | 542.5 | 538.7 | 530.1 | 520.9 | 514.2 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | **Δ Tv** | 2.84 | 3.20 | 3.46 | 3.57 | 3.71 | 3.78 | 3.79 | 3.80 | 3.71 | 3.77 | 3.26 | 2.90 |
| | | **Tla** | 512.64 | 516.16 | 522.85 | 528.91 | 536.18 | 541.72 | 543.51 | 543.28 | 539.44 | 530.79 | 521.43 | 514.63 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 1 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Gasoline RVP 13 | 62 | 0.2411 | 0.2271 | 0.2081 | 0.1905 | 0.1693 | 0.1577 | 0.1531 | 0.1531 | 0.1623 | 0.1852 | 0.2114 | 0.2339 |
| Kerosene | kerosene (Fuel Oil #1) | 170 | 0.9883 | 0.9865 | 0.9839 | 0.9812 | 0.9762 | 0.9723 | 0.9703 | 0.9703 | 0.9741 | 0.9803 | 0.9843 | 0.9874 |
| | jet kerosene (Jet A) | 130 | 0.9966 | 0.9960 | 0.9953 | 0.9945 | 0.9929 | 0.9918 | 0.9912 | 0.9912 | 0.9923 | 0.9942 | 0.9954 | 0.9963 |
| | jet naphtha (JP-4) | 80 | 0.6403 | 0.6152 | 0.5811 | 0.5506 | 0.5146 | 0.4918 | 0.4793 | 0.4793 | 0.5022 | 0.5411 | 0.5865 | 0.6275 |
| Naphtha and Solvents | Naphtha | 110 | 0.9196 | 0.9158 | 0.9102 | 0.9047 | 0.8974 | 0.8929 | 0.8911 | 0.8911 | 0.8947 | 0.9029 | 0.9112 | 0.9177 |
| | Coker gas | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Cat Gas | 80 | 0.6403 | 0.6152 | 0.5811 | 0.5506 | 0.5146 | 0.4918 | 0.4793 | 0.4793 | 0.5022 | 0.5411 | 0.5865 | 0.6275 |
| | Alkylates | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organic Compounds NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Other Hydrocarbons | Styrene | 104.14 | 0.9612 | 0.9579 | 0.9529 | 0.9432 | 0.9276 | 0.9182 | 0.9144 | 0.9144 | 0.9219 | 0.9393 | 0.9537 | 0.9596 |
| | Cumene | 120.2 | 0.9759 | 0.9723 | 0.9670 | 0.9617 | 0.9547 | 0.9490 | 0.9446 | 0.9446 | 0.9521 | 0.9599 | 0.9679 | 0.9741 |
| | MEK | 72.1 | 0.6576 | 0.6337 | 0.6002 | 0.5687 | 0.5067 | 0.4699 | 0.4562 | 0.4562 | 0.4841 | 0.5589 | 0.6058 | 0.6455 |
| | MTBE | 88.15 | 0.3594 | 0.3361 | 0.3089 | 0.2904 | 0.2490 | 0.2257 | 0.2181 | 0.2181 | 0.2343 | 0.2847 | 0.3123 | 0.3473 |
| | Butyl Acrylate | 128.17 | 0.9705 | 0.9670 | 0.9617 | 0.9564 | 0.9478 | 0.9373 | 0.9331 | 0.9331 | 0.9415 | 0.9547 | 0.9625 | 0.9687 |
| | Vinyl Acetate | 86.09 | 0.6429 | 0.6168 | 0.5774 | 0.5356 | 0.4798 | 0.4456 | 0.4284 | 0.4284 | 0.4608 | 0.5230 | 0.5850 | 0.6296 |
| | Xylene | 106.17 | 0.9600 | 0.9565 | 0.9513 | 0.9380 | 0.9209 | 0.9105 | 0.9070 | 0.9070 | 0.9146 | 0.9337 | 0.9521 | 0.9583 |
| | Propyl Acetate | 102.13 | 0.8633 | 0.8481 | 0.8236 | 0.7889 | 0.7470 | 0.7229 | 0.7138 | 0.7138 | 0.7324 | 0.7780 | 0.8299 | 0.8556 |
| | MIBK | 100.16 | 0.9664 | 0.9623 | 0.9562 | 0.9486 | 0.9297 | 0.9182 | 0.9137 | 0.9137 | 0.9228 | 0.9438 | 0.9572 | 0.9643 |
| Petroleum Products NEC | Lube oil | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| | Light and Heavy Cycle Oils | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 0.9999 |
| Residual Fuel Oil | Residual Fuel | 190 | 0.9983 | 0.9981 | 0.9976 | 0.9970 | 0.9958 | 0.9950 | 0.9945 | 0.9945 | 0.9953 | 0.9968 | 0.9977 | 0.9982 |
| | Marine Residual Fuel | 190 | 0.9888 | 0.9875 | 0.9847 | 0.9806 | 0.9732 | 0.9679 | 0.9652 | 0.9652 | 0.9702 | 0.9792 | 0.9854 | 0.9881 |
| | No. 6 Fuel Oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.9999 | 0.9999 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| | | | Corpus Christi - Empty | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 516.1 | 519.5 | 526 | 531.5 | 537.5 | 541.9 | 543.8 | 543.9 | 540.8 | 533.8 | 525.1 | 518.1 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | **Δ Tv** | 33.59 | 39.38 | 44.90 | 48.60 | 51.77 | 57.11 | 60.60 | 56.48 | 49.50 | 44.60 | 36.50 | 32.52 |
| | | **Tla** | 521.56 | 526.47 | 534.69 | 541.48 | 548.84 | 554.62 | 557.08 | 556.00 | 551.05 | 542.40 | 531.44 | 523.23 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 5 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 100.2 | 0.7710 | 0.7416 | 0.6951 | 0.6549 | 0.6145 | 0.5781 | 0.5601 | 0.5720 | 0.5972 | 0.6488 | 0.7133 | 0.7590 |
| | n-decane | 142.29 | 0.9903 | 0.9864 | 0.9796 | 0.9737 | 0.9679 | 0.9629 | 0.9605 | 0.9621 | 0.9654 | 0.9729 | 0.9821 | 0.9890 |
| | 1-heptene | 98.19 | 0.7543 | 0.7306 | 0.6877 | 0.6460 | 0.6042 | 0.5631 | 0.5445 | 0.5567 | 0.5829 | 0.6405 | 0.7093 | 0.7446 |
| | hexane | 86.17 | 0.4941 | 0.4603 | 0.4128 | 0.3753 | 0.3356 | 0.3050 | 0.2910 | 0.3002 | 0.3203 | 0.3691 | 0.4303 | 0.4800 |
| | nonene | 126.24 | 0.9303 | 0.9281 | 0.9246 | 0.9215 | 0.9185 | 0.9159 | 0.9146 | 0.9155 | 0.9172 | 0.9211 | 0.9259 | 0.9294 |
| Alcohols | methanol | 32.04 | 0.5627 | 0.5207 | 0.4599 | 0.4118 | 0.3644 | 0.3268 | 0.3097 | 0.3209 | 0.3459 | 0.4043 | 0.4831 | 0.5451 |
| | ethanol | 46.07 | 0.7455 | 0.7103 | 0.6515 | 0.5988 | 0.5428 | 0.4934 | 0.4699 | 0.4853 | 0.5194 | 0.5901 | 0.6759 | 0.7310 |
| | isopropanol | 60.09 | 0.7897 | 0.7589 | 0.7082 | 0.6617 | 0.6068 | 0.5589 | 0.5359 | 0.5510 | 0.5839 | 0.6532 | 0.7288 | 0.7771 |
| | butanols (iso Butyl Alcohol) | 74.12 | 0.9306 | 0.9174 | 0.8938 | 0.8697 | 0.8384 | 0.8079 | 0.7922 | 0.8026 | 0.8242 | 0.8651 | 0.9038 | 0.9253 |
| | decanol | 158.28 | 1.0000 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 1.0000 |
| | hexanol | 102.18 | 0.9866 | 0.9811 | 0.9725 | 0.9651 | 0.9578 | 0.9516 | 0.9462 | 0.9513 | 0.9547 | 0.9640 | 0.9757 | 0.9844 |
| | 2-ethylhexanol | 130.2 | 0.9973 | 0.9968 | 0.9957 | 0.9946 | 0.9931 | 0.9915 | 0.9906 | 0.9912 | 0.9924 | 0.9944 | 0.9962 | 0.9971 |
| Benzene/Toluene | Benzene | 78.11 | 0.6123 | 0.5796 | 0.5270 | 0.4810 | 0.4318 | 0.3958 | 0.3796 | 0.3902 | 0.4134 | 0.4733 | 0.5483 | 0.5988 |
| | Toluene | 92.13 | 0.8548 | 0.8329 | 0.7948 | 0.7589 | 0.7198 | 0.6854 | 0.6684 | 0.6796 | 0.7032 | 0.7531 | 0.8107 | 0.8459 |
| Carboxylic Acids | acetic acid | 60.05 | 0.9116 | 0.8983 | 0.8696 | 0.8460 | 0.8181 | 0.7846 | 0.7689 | 0.7793 | 0.8010 | 0.8427 | 0.8802 | 0.9074 |
| | propionic acid | 74.08 | 0.9702 | 0.9657 | 0.9585 | 0.9522 | 0.9382 | 0.9256 | 0.9193 | 0.9235 | 0.9318 | 0.9513 | 0.9612 | 0.9684 |
| | butyric acid | 88.12 | 0.9975 | 0.9954 | 0.9917 | 0.9871 | 0.9808 | 0.9754 | 0.9727 | 0.9745 | 0.9781 | 0.9862 | 0.9931 | 0.9968 |
| Chemical Products NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Chemical Additives | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Crude Petroleum | crude oil | 50 | 0.6528 | 0.6299 | 0.5963 | 0.5686 | 0.5368 | 0.5103 | 0.4976 | 0.5060 | 0.5237 | 0.5638 | 0.6085 | 0.6434 |
| | crude oil RVP 5 | 50 | 0.3975 | 0.3739 | 0.3414 | 0.3162 | 0.2891 | 0.2678 | 0.2579 | 0.2644 | 0.2784 | 0.3120 | 0.3529 | 0.3877 |
| Distillate Fuel Oils | #1 diesel | 180 | 0.9845 | 0.9817 | 0.9768 | 0.9719 | 0.9658 | 0.9589 | 0.9551 | 0.9576 | 0.9628 | 0.9711 | 0.9788 | 0.9834 |
| | #2 diesel | 130 | 0.9964 | 0.9958 | 0.9946 | 0.9935 | 0.9920 | 0.9903 | 0.9894 | 0.9900 | 0.9913 | 0.9933 | 0.9951 | 0.9962 |
| | marine diesel oil | 130 | 0.9964 | 0.9958 | 0.9946 | 0.9935 | 0.9920 | 0.9903 | 0.9894 | 0.9900 | 0.9913 | 0.9933 | 0.9951 | 0.9962 |
| | gas oil | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Gasoline | Gasoline RVP 6 | 68 | 0.3695 | 0.3458 | 0.3125 | 0.2869 | 0.2618 | 0.2417 | 0.2323 | 0.2385 | 0.2518 | 0.2830 | 0.3246 | 0.3596 |
| | Gasoline RVP 7 | 68 | 0.3451 | 0.3216 | 0.2882 | 0.2625 | 0.2392 | 0.2202 | 0.2114 | 0.2172 | 0.2299 | 0.2589 | 0.3006 | 0.3353 |
| | Gasoline RVP 7.8 | 68 | 0.3193 | 0.2977 | 0.2665 | 0.2420 | 0.2191 | 0.2012 | 0.1929 | 0.1984 | 0.2102 | 0.2384 | 0.2783 | 0.3103 |
| | Gasoline RVP 8.3 | 68 | 0.3045 | 0.2837 | 0.2536 | 0.2301 | 0.2083 | 0.1911 | 0.1832 | 0.1884 | 0.1997 | 0.2267 | 0.2650 | 0.2958 |
| | Gasoline RVP 10 | 66 | 0.2625 | 0.2455 | 0.2202 | 0.2002 | 0.1813 | 0.1660 | 0.1589 | 0.1635 | 0.1738 | 0.1972 | 0.2299 | 0.2554 |
| | Gasoline RVP 11.5 | 65 | 0.2335 | 0.2168 | 0.1930 | 0.1746 | 0.1577 | 0.1446 | 0.1386 | 0.1425 | 0.1512 | 0.1720 | 0.2019 | 0.2265 |

| | | | Corpus Christi - Empty | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Min. Liq. Temp** | 516.1 | 519.5 | 526 | 531.5 | 537.5 | 541.9 | 543.8 | 543.9 | 540.8 | 533.8 | 525.1 | 518.1 |
| | | **Pa** | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 |
| | | **Δ Pb** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | **Δ Tv** | 33.59 | 39.38 | 44.90 | 48.60 | 51.77 | 57.11 | 60.60 | 56.48 | 49.50 | 44.60 | 36.50 | 32.52 |
| | | **Tla** | 521.56 | 526.47 | 534.69 | 541.48 | 548.84 | 554.62 | 557.08 | 556.00 | 551.05 | 542.40 | 531.44 | 523.23 |
| | | | **Values for Vented Vapor Saturation Factor (Ks) in Various Months of the Year for Trip Length = 5 hours** | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Molecular weight** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Gasoline RVP 13 | 62 | 0.2114 | 0.1960 | 0.1743 | 0.1577 | 0.1426 | 0.1308 | 0.1253 | 0.1289 | 0.1368 | 0.1553 | 0.1824 | 0.2049 |
| Kerosene | kerosene (Fuel Oil #1) | 170 | 0.9843 | 0.9821 | 0.9775 | 0.9723 | 0.9652 | 0.9577 | 0.9537 | 0.9563 | 0.9618 | 0.9713 | 0.9796 | 0.9834 |
| | jet kerosene (Jet A) | 130 | 0.9954 | 0.9947 | 0.9934 | 0.9918 | 0.9896 | 0.9873 | 0.9861 | 0.9869 | 0.9886 | 0.9915 | 0.9940 | 0.9951 |
| | jet naphtha (JP-4) | 80 | 0.5865 | 0.5604 | 0.5231 | 0.4918 | 0.4507 | 0.4282 | 0.4196 | 0.4253 | 0.4371 | 0.4854 | 0.5365 | 0.5758 |
| Naphtha and Solvents | Naphtha | 110 | 0.9112 | 0.9065 | 0.8992 | 0.8929 | 0.8867 | 0.8815 | 0.8789 | 0.8806 | 0.8841 | 0.8920 | 0.9019 | 0.9093 |
| | Coker gas | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | Cat Gas | 80 | 0.5865 | 0.5604 | 0.5231 | 0.4918 | 0.4507 | 0.4282 | 0.4196 | 0.4253 | 0.4371 | 0.4854 | 0.5365 | 0.5758 |
| | Alkylates | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organic Compounds NEC | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Other Hydrocarbons | Styrene | 104.14 | 0.9537 | 0.9472 | 0.9315 | 0.9182 | 0.9037 | 0.8839 | 0.8743 | 0.8807 | 0.8937 | 0.9163 | 0.9373 | 0.9521 |
| | Cumene | 120.2 | 0.9679 | 0.9634 | 0.9564 | 0.9490 | 0.9337 | 0.9209 | 0.9146 | 0.9188 | 0.9272 | 0.9468 | 0.9590 | 0.9661 |
| | MEK | 72.1 | 0.6058 | 0.5788 | 0.5230 | 0.4699 | 0.4254 | 0.3910 | 0.3752 | 0.3856 | 0.4082 | 0.4629 | 0.5495 | 0.5947 |
| | MTBE | 88.15 | 0.3123 | 0.2963 | 0.2599 | 0.2257 | 0.2010 | 0.1838 | 0.1762 | 0.1812 | 0.1920 | 0.2219 | 0.2781 | 0.3057 |
| | Butyl Acrylate | 128.17 | 0.9625 | 0.9582 | 0.9513 | 0.9373 | 0.9229 | 0.9110 | 0.9035 | 0.9090 | 0.9169 | 0.9352 | 0.9538 | 0.9608 |
| | Vinyl Acetate | 86.09 | 0.5850 | 0.5488 | 0.4934 | 0.4456 | 0.3907 | 0.3518 | 0.3348 | 0.3459 | 0.3706 | 0.4369 | 0.5153 | 0.5700 |
| | Xylene | 106.17 | 0.9521 | 0.9424 | 0.9251 | 0.9105 | 0.8891 | 0.8685 | 0.8585 | 0.8651 | 0.8787 | 0.9085 | 0.9315 | 0.9490 |
| | Propyl Acetate | 102.13 | 0.8299 | 0.8001 | 0.7570 | 0.7229 | 0.6824 | 0.6457 | 0.6288 | 0.6399 | 0.6635 | 0.7183 | 0.7726 | 0.8176 |
| | MIBK | 100.16 | 0.9572 | 0.9522 | 0.9344 | 0.9182 | 0.8984 | 0.8736 | 0.8617 | 0.8696 | 0.8859 | 0.9160 | 0.9414 | 0.9552 |
| Petroleum Products NEC | Lube oil | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9997 | 0.9998 | 0.9998 | 0.9999 | 0.9999 |
| | Light and Heavy Cycle Oils | 190 | 0.9999 | 0.9999 | 0.9999 | 0.9998 | 0.9998 | 0.9997 | 0.9997 | 0.9997 | 0.9998 | 0.9998 | 0.9999 | 0.9999 |
| Residual Fuel Oil | Residual Fuel | 190 | 0.9977 | 0.9972 | 0.9961 | 0.9950 | 0.9935 | 0.9918 | 0.9908 | 0.9915 | 0.9927 | 0.9948 | 0.9966 | 0.9975 |
| | Marine Residual Fuel | 190 | 0.9854 | 0.9820 | 0.9752 | 0.9679 | 0.9587 | 0.9484 | 0.9428 | 0.9465 | 0.9542 | 0.9666 | 0.9782 | 0.9840 |
| | No. 6 Fuel Oil | 190 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 1.0000 | 1.0000 |

# Appendix E
# Emission Factors (Base Case, 1 psi Barges)

## *LOADED BARGES – CONTROLLED SCENARIO*

**EMISSION FACTORS (POUNDS PER BARREL OF PRODUCT SHIPPED) FOR LOADED BARGES**

**STANDING STORAGE LOSS ( Ls )**
Ls = Vv Wv Ke Ks
where:
Ls = standing storage loss, lb/bbl/yr
Vv = vapor space volume, ft3
Wv = stock vapor density, lb/ft3
Ke = vapor space expansion factor, dimensionless
Ks = vented vapor saturation factor, dimensionless
bbl (USP)/cubic foot 0.1781

**ALL OF THESE EMISSION FACTORS ARE FOR PRODUCT SHIPPED IN ONE POUND BARGES**

**0.030927835**

## *Houston*

| | | Houston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Houston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0000 | 0.0000 | 0.0000 | | | | | | | 0.0000 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Houston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Houston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0000 | 0.0001 | 0.0002 | | | | | | | 0.0006 | 0.0001 | 0.0000 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0001 | 0.0001 | 0.0006 | 0.0013 | 0.0013 | 0.0014 | 0.0014 | 0.0013 | 0.0009 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Houston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |

| | | Houston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0001 | 0.0003 | 0.0004 | 0.0007 | 0.0010 | 0.0010 | 0.0009 | 0.0006 | 0.0003 | 0.0001 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0005 | 0.0005 | 0.0004 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0005 | 0.0006 | 0.0007 | 0.0006 | 0.0004 | 0.0002 | 0.0001 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0004 | 0.0008 | 0.0010 | 0.0010 | 0.0009 | 0.0006 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0001 | 0.0004 | 0.0008 | | | | | | | 0.0012 | 0.0004 | 0.0001 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| | MTBE | 0.0002 | 0.0004 | 0.0005 | 0.0018 | 0.0033 | 0.0037 | 0.0039 | 0.0033 | 0.0024 | 0.0017 | 0.0002 | 0.0002 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0006 | 0.0008 | 0.0008 | 0.0007 | 0.0005 | 0.0002 | 0.0001 | 0.0000 |

| | | Houston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

## *Galveston*

| | | Galveston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0000 | 0.0000 | 0.0000 | | | | | | | 0.0000 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |

| | | Galveston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0000 | 0.0001 | 0.0002 | | | | | | | 0.0006 | 0.0001 | 0.0000 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0007 | 0.0011 | 0.0012 | 0.0012 | 0.0012 | 0.0008 | 0.0008 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0006 | 0.0009 | 0.0009 | 0.0008 | 0.0005 | 0.0002 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0003 | 0.0004 | 0.0004 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0006 | 0.0005 | 0.0003 | 0.0001 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0004 | 0.0008 | 0.0010 | 0.0010 | 0.0009 | 0.0006 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0001 | 0.0004 | 0.0008 | | | | | | | 0.0012 | 0.0004 | 0.0001 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0004 | 0.0004 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0001 | 0.0004 | 0.0020 | 0.0031 | 0.0036 | 0.0037 | 0.0031 | 0.0023 | 0.0013 | 0.0001 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0005 | 0.0007 | 0.0007 | 0.0006 | 0.0004 | 0.0001 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

## *Port Arthur*

| | | Port Arthur – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 1 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | | | | | | | | | |
| | HGB Winter Gasoline RVP 10.9 | | | | | | | | | | | | |
| | BPA Summer Gasoline RVP 6.1 | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| | BPA Winter Gasoline RVP 12.2 | 0.0000 | 0.0000 | 0.0000 | | | | | | | 0.0000 | 0.0000 | 0.0000 |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 1 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 3 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 3 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | | | | | | | | | |
| | HGB Winter Gasoline RVP 10.9 | | | | | | | | | | | | |
| | BPA Summer Gasoline RVP 6.1 | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| | BPA Winter Gasoline RVP 12.2 | 0.0000 | 0.0000 | 0.0000 | | | | | | | 0.0000 | 0.0000 | 0.0000 |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | | | | | | | | | |
| | HGB Winter Gasoline RVP 10.9 | | | | | | | | | | | | |
| | BPA Summer Gasoline RVP 6.1 | | | | 0.0001 | 0.0002 | 0.0004 | 0.0003 | 0.0003 | 0.0003 | | | |
| | BPA Winter Gasoline RVP 12.2 | 0.0000 | 0.0001 | 0.0005 | | | | | | | 0.0009 | 0.0002 | 0.0000 |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0001 | 0.0001 | 0.0005 | 0.0013 | 0.0017 | 0.0013 | 0.0013 | 0.0013 | 0.0009 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

## *Corpus Christi*

| | | Corpus Christi – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0003 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0002 | 0.0003 | 0.0005 | 0.0008 | 0.0013 | 0.0015 | 0.0012 | 0.0009 | 0.0004 | 0.0001 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0004 | 0.0003 | 0.0001 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0007 | 0.0006 | 0.0004 | 0.0002 | 0.0001 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0005 | 0.0008 | 0.0010 | 0.0008 | 0.0006 | 0.0003 | 0.0001 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | | | | | | | | | |
| | HGB Winter Gasoline RVP 10.9 | | | | | | | | | | | | |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | 0.0010 | 0.0014 | 0.0023 | 0.0029 | 0.0022 | 0.0016 | | | |
| | CC Winter Gasoline RVP 12.4 | 0.0003 | 0.0009 | 0.0017 | | | | | | | 0.0029 | 0.0007 | 0.0003 |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0004 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0004 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Corpus Christi – Loaded Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0001 | 0.0001 | 0.0003 | 0.0004 | 0.0005 | 0.0007 | 0.0005 | 0.0004 | 0.0002 | 0.0000 | 0.0000 |
| | MTBE | 0.0002 | 0.0003 | 0.0010 | 0.0026 | 0.0034 | 0.0049 | 0.0059 | 0.0045 | 0.0035 | 0.0022 | 0.0003 | 0.0001 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0010 | 0.0012 | 0.0009 | 0.0007 | 0.0003 | 0.0001 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

## *EMPTY BARGES – CONTROLLED SCENARIO*

**EMISSION FACTORS (POUNDS PER BARREL OF PRODUCT SHIPPED) FOR EMPTY BARGES**

**STANDING STORAGE LOSS ( Ls )**

Ls = Vv Wv Ke Ks
where:
Ls = standing storage loss, lb/bbl/yr
Vv = vapor space volume, ft3
Wv = stock vapor density, lb/ft3
Ke = vapor space expansion factor, dimensionless
Ks = vented vapor saturation factor, dimensionless
bbl (USP)/cubic foot 0.1781

**ALL OF THESE EMISSION FACTORS ARE FOR PRODUCT SHIPPED IN ONE POUND BARGES**

**1.030927835**

## *Houston*

| | | Houston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Houston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0000 | 0.0000 | 0.0000 | | | | | | | 0.0000 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Houston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0006 | 0.0006 | 0.0005 | 0.0005 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0005 | 0.0006 | 0.0008 | 0.0008 | 0.0005 | 0.0005 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0002 | 0.0012 | 0.0013 | 0.0023 | 0.0034 | 0.0035 | 0.0035 | 0.0030 | 0.0018 | 0.0005 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0001 | 0.0004 | 0.0005 | 0.0009 | 0.0013 | 0.0013 | 0.0013 | 0.0011 | 0.0007 | 0.0002 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0005 | 0.0007 | 0.0007 | 0.0007 | 0.0006 | 0.0004 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0006 | 0.0006 | 0.0006 | 0.0005 | 0.0003 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0004 | 0.0007 | 0.0013 | 0.0019 | 0.0020 | 0.0020 | 0.0017 | 0.0011 | 0.0001 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0007 | 0.0006 | 0.0011 | 0.0017 | 0.0017 | 0.0017 | 0.0015 | 0.0008 | 0.0002 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0008 | 0.0017 | 0.0023 | 0.0023 | 0.0023 | 0.0017 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0000 | 0.0006 | 0.0018 | | | | | | | 0.0040 | 0.0008 | 0.0000 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0003 | 0.0003 | 0.0007 | 0.0013 | 0.0013 | 0.0013 | 0.0011 | 0.0005 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0003 | 0.0003 | 0.0007 | 0.0013 | 0.0013 | 0.0013 | 0.0011 | 0.0005 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0002 | 0.0008 | 0.0015 | 0.0016 | 0.0016 | 0.0016 | 0.0016 | 0.0013 | 0.0000 | 0.0000 |
| | MTBE | 0.0001 | 0.0015 | 0.0009 | 0.0054 | 0.0104 | 0.0099 | 0.0101 | 0.0101 | 0.0102 | 0.0084 | 0.0000 | 0.0001 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0007 | 0.0010 | 0.0020 | 0.0034 | 0.0034 | 0.0034 | 0.0028 | 0.0015 | 0.0002 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0004 | 0.0005 | 0.0005 | 0.0003 | 0.0003 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Houston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0006 | 0.0014 | 0.0022 | 0.0033 | 0.0039 | 0.0040 | 0.0034 | 0.0024 | 0.0017 | 0.0005 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0006 | 0.0013 | 0.0022 | 0.0033 | 0.0042 | 0.0043 | 0.0037 | 0.0024 | 0.0018 | 0.0004 | 0.0000 |
| | hexane | 0.0005 | 0.0018 | 0.0040 | 0.0055 | 0.0089 | 0.0110 | 0.0112 | 0.0096 | 0.0069 | 0.0044 | 0.0018 | 0.0004 |
| | nonene | 0.0000 | 0.0002 | 0.0003 | 0.0005 | 0.0006 | 0.0007 | 0.0006 | 0.0006 | 0.0004 | 0.0003 | 0.0001 | 0.0000 |
| Alcohols | methanol | 0.0002 | 0.0006 | 0.0013 | 0.0020 | 0.0032 | 0.0040 | 0.0041 | 0.0035 | 0.0025 | 0.0017 | 0.0006 | 0.0001 |
| | ethanol | 0.0001 | 0.0004 | 0.0008 | 0.0014 | 0.0022 | 0.0028 | 0.0030 | 0.0025 | 0.0017 | 0.0011 | 0.0003 | 0.0000 |
| | isopropanol | 0.0000 | 0.0003 | 0.0008 | 0.0013 | 0.0022 | 0.0028 | 0.0029 | 0.0025 | 0.0017 | 0.0010 | 0.0003 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0001 | 0.0003 | 0.0005 | 0.0008 | 0.0010 | 0.0011 | 0.0009 | 0.0006 | 0.0004 | 0.0001 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0002 | 0.0010 | 0.0022 | 0.0034 | 0.0056 | 0.0068 | 0.0068 | 0.0058 | 0.0043 | 0.0028 | 0.0009 | 0.0001 |
| | Toluene | 0.0000 | 0.0003 | 0.0008 | 0.0012 | 0.0020 | 0.0024 | 0.0024 | 0.0021 | 0.0014 | 0.0010 | 0.0002 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0001 | 0.0003 | 0.0005 | 0.0007 | 0.0010 | 0.0010 | 0.0008 | 0.0005 | 0.0004 | 0.0001 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0004 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0003 | 0.0012 | 0.0026 | 0.0033 | 0.0052 | 0.0063 | 0.0064 | 0.0054 | 0.0039 | 0.0025 | 0.0011 | 0.0002 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0004 | 0.0005 | 0.0005 | 0.0004 | 0.0002 | 0.0002 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0048 | 0.0077 | 0.0092 | 0.0094 | 0.0079 | 0.0057 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0009 | 0.0033 | 0.0067 | | | | | | | 0.0087 | 0.0031 | 0.0007 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0004 | 0.0002 | 0.0002 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0002 | 0.0011 | 0.0021 | 0.0028 | 0.0045 | 0.0053 | 0.0049 | 0.0043 | 0.0035 | 0.0021 | 0.0007 | 0.0001 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0002 | 0.0004 | 0.0006 | 0.0007 | 0.0008 | 0.0008 | 0.0007 | 0.0005 | 0.0004 | 0.0001 | 0.0000 |
| | "Solvents" (JP-4) | 0.0002 | 0.0011 | 0.0021 | 0.0028 | 0.0045 | 0.0053 | 0.0049 | 0.0043 | 0.0035 | 0.0021 | 0.0007 | 0.0001 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0008 | 0.0008 | 0.0007 | 0.0004 | 0.0003 | 0.0001 | 0.0000 |

| | | Houston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | Cumene | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0005 | 0.0006 | 0.0006 | 0.0005 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| | MEK | 0.0001 | 0.0009 | 0.0018 | 0.0036 | 0.0054 | 0.0061 | 0.0061 | 0.0052 | 0.0040 | 0.0031 | 0.0006 | 0.0001 |
| | MTBE | 0.0020 | 0.0040 | 0.0049 | 0.0156 | 0.0252 | 0.0264 | 0.0270 | 0.0230 | 0.0183 | 0.0152 | 0.0017 | 0.0019 |
| | Butyl Acrylate | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0008 | 0.0008 | 0.0006 | 0.0004 | 0.0003 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0002 | 0.0012 | 0.0029 | 0.0044 | 0.0079 | 0.0100 | 0.0101 | 0.0088 | 0.0063 | 0.0036 | 0.0012 | 0.0002 |
| | Xylene | 0.0000 | 0.0001 | 0.0003 | 0.0005 | 0.0007 | 0.0010 | 0.0010 | 0.0008 | 0.0005 | 0.0003 | 0.0001 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0004 | 0.0011 | 0.0017 | 0.0025 | 0.0032 | 0.0032 | 0.0028 | 0.0018 | 0.0013 | 0.0004 | 0.0000 |
| | MIBK | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0009 | 0.0009 | 0.0007 | 0.0004 | 0.0003 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

## *Galveston*

| | | Galveston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 2 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0000 | 0.0000 | 0.0000 | | | | | | | 0.0000 | 0.0000 | 0.0000 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0016 | 0.0025 | 0.0025 | 0.0025 | 0.0016 | 0.0004 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0007 | 0.0009 | 0.0010 | 0.0010 | 0.0006 | 0.0003 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0003 | 0.0003 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0007 | 0.0012 | 0.0012 | 0.0012 | 0.0007 | 0.0001 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0007 | 0.0011 | 0.0011 | 0.0011 | 0.0005 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0008 | 0.0017 | 0.0023 | 0.0023 | 0.0023 | 0.0017 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0000 | 0.0006 | 0.0018 | | | | | | | 0.0040 | 0.0008 | 0.0000 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0006 | 0.0004 | 0.0004 | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0006 | 0.0004 | 0.0004 | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0008 | 0.0009 | 0.0009 | 0.0009 | 0.0005 | 0.0004 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0067 | 0.0092 | 0.0089 | 0.0089 | 0.0089 | 0.0060 | 0.0069 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0014 | 0.0025 | 0.0025 | 0.0025 | 0.0017 | 0.0003 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0006 | 0.0014 | 0.0024 | 0.0030 | 0.0029 | 0.0024 | 0.0015 | 0.0006 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0005 | 0.0014 | 0.0024 | 0.0033 | 0.0033 | 0.0027 | 0.0017 | 0.0007 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0009 | 0.0023 | 0.0042 | 0.0077 | 0.0097 | 0.0098 | 0.0082 | 0.0060 | 0.0024 | 0.0005 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0004 | 0.0003 | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0003 | 0.0008 | 0.0016 | 0.0028 | 0.0036 | 0.0037 | 0.0031 | 0.0022 | 0.0010 | 0.0002 | 0.0000 |
| | ethanol | 0.0000 | 0.0001 | 0.0004 | 0.0010 | 0.0018 | 0.0024 | 0.0024 | 0.0020 | 0.0013 | 0.0005 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0004 | 0.0009 | 0.0017 | 0.0023 | 0.0023 | 0.0019 | 0.0012 | 0.0004 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0001 | 0.0003 | 0.0005 | 0.0007 | 0.0007 | 0.0006 | 0.0003 | 0.0001 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0003 | 0.0011 | 0.0025 | 0.0046 | 0.0057 | 0.0056 | 0.0047 | 0.0035 | 0.0014 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0003 | 0.0007 | 0.0014 | 0.0018 | 0.0017 | 0.0014 | 0.0008 | 0.0003 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0001 | 0.0003 | 0.0005 | 0.0007 | 0.0007 | 0.0005 | 0.0003 | 0.0001 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0005 | 0.0014 | 0.0024 | 0.0045 | 0.0055 | 0.0055 | 0.0046 | 0.0033 | 0.0012 | 0.0001 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | 0.0048 | 0.0077 | 0.0092 | 0.0094 | 0.0079 | 0.0057 | | | |
| | HGB Winter Gasoline RVP 10.9 | 0.0009 | 0.0033 | 0.0067 | | | | | | | 0.0087 | 0.0031 | 0.0007 |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0002 | 0.0009 | 0.0017 | 0.0036 | 0.0041 | 0.0036 | 0.0030 | 0.0027 | 0.0008 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0005 | 0.0005 | 0.0004 | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0002 | 0.0009 | 0.0017 | 0.0036 | 0.0041 | 0.0036 | 0.0030 | 0.0027 | 0.0008 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Galveston – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0005 | 0.0005 | 0.0004 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0003 | 0.0004 | 0.0004 | 0.0003 | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0002 | 0.0009 | 0.0030 | 0.0044 | 0.0051 | 0.0050 | 0.0042 | 0.0030 | 0.0017 | 0.0000 | 0.0000 |
| | MTBE | 0.0004 | 0.0015 | 0.0035 | 0.0168 | 0.0235 | 0.0250 | 0.0254 | 0.0214 | 0.0167 | 0.0109 | 0.0009 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0005 | 0.0005 | 0.0003 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0005 | 0.0016 | 0.0034 | 0.0069 | 0.0088 | 0.0088 | 0.0074 | 0.0057 | 0.0021 | 0.0001 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0005 | 0.0007 | 0.0006 | 0.0005 | 0.0003 | 0.0001 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0005 | 0.0010 | 0.0017 | 0.0024 | 0.0023 | 0.0019 | 0.0012 | 0.0004 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0006 | 0.0005 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

### *Port Arthur*

| | | Port Arthur – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 1 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 1 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | | | | | | | | | |
| | HGB Winter Gasoline RVP 10.9 | | | | | | | | | | | | |
| | BPA Summer Gasoline RVP 6.1 | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| | BPA Winter Gasoline RVP 12.2 | 0.0000 | 0.0000 | 0.0000 | | | | | | | 0.0000 | 0.0000 | 0.0000 |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 3 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 3 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | | | | | | | | | |
| | HGB Winter Gasoline RVP 10.9 | | | | | | | | | | | | |
| | BPA Summer Gasoline RVP 6.1 | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| | BPA Winter Gasoline RVP 12.2 | 0.0000 | 0.0000 | 0.0000 | | | | | | | 0.0000 | 0.0000 | 0.0000 |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0004 | 0.0006 | 0.0005 | 0.0005 | 0.0004 | 0.0003 | 0.0000 | 0.0000 |
| | n-decane | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0004 | 0.0007 | 0.0006 | 0.0006 | 0.0004 | 0.0004 | 0.0000 | 0.0000 |
| | hexane | 0.0000 | 0.0000 | 0.0010 | 0.0012 | 0.0022 | 0.0041 | 0.0033 | 0.0033 | 0.0028 | 0.0015 | 0.0003 | 0.0000 |
| | nonene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Alcohols | methanol | 0.0000 | 0.0000 | 0.0003 | 0.0005 | 0.0009 | 0.0015 | 0.0012 | 0.0012 | 0.0011 | 0.0006 | 0.0001 | 0.0000 |
| | ethanol | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0007 | 0.0006 | 0.0006 | 0.0005 | 0.0003 | 0.0000 | 0.0000 |
| | isopropanol | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0003 | 0.0006 | 0.0005 | 0.0005 | 0.0004 | 0.0002 | 0.0000 | 0.0000 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0000 | 0.0000 | 0.0003 | 0.0005 | 0.0012 | 0.0022 | 0.0018 | 0.0018 | 0.0015 | 0.0009 | 0.0000 | 0.0000 |
| | Toluene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | propionic acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0000 | 0.0000 | 0.0005 | 0.0005 | 0.0011 | 0.0021 | 0.0016 | 0.0016 | 0.0014 | 0.0007 | 0.0001 | 0.0000 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | | | | | | | | | |
| | HGB Winter Gasoline RVP 10.9 | | | | | | | | | | | | |
| | BPA Summer Gasoline RVP 6.1 | | | | 0.0012 | 0.0022 | 0.0037 | 0.0028 | 0.0028 | 0.0025 | | | |
| | BPA Winter Gasoline RVP 12.2 | 0.0000 | 0.0010 | 0.0038 | | | | | | | 0.0058 | 0.0019 | 0.0000 |
| | CC Summer Gasoline RVP 7.5 | | | | | | | | | | | | |
| | CC Winter Gasoline RVP 12.4 | | | | | | | | | | | | |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0006 | 0.0015 | 0.0012 | 0.0012 | 0.0009 | 0.0003 | 0.0000 | 0.0000 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | "Solvents" (JP-4) | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0006 | 0.0015 | 0.0012 | 0.0012 | 0.0009 | 0.0003 | 0.0000 | 0.0000 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | Port Arthur – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 9 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Cumene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | MEK | 0.0000 | 0.0000 | 0.0001 | 0.0007 | 0.0014 | 0.0019 | 0.0015 | 0.0015 | 0.0014 | 0.0012 | 0.0000 | 0.0000 |
| | MTBE | 0.0000 | 0.0012 | 0.0006 | 0.0052 | 0.0103 | 0.0124 | 0.0098 | 0.0098 | 0.0099 | 0.0081 | 0.0000 | 0.0000 |
| | Butyl Acrylate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Vinyl Acetate | 0.0000 | 0.0000 | 0.0005 | 0.0009 | 0.0019 | 0.0039 | 0.0032 | 0.0032 | 0.0026 | 0.0013 | 0.0001 | 0.0000 |
| | Xylene | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Propyl Acetate | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0004 | 0.0004 | 0.0004 | 0.0002 | 0.0002 | 0.0000 | 0.0000 |
| | MIBK | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

## *Corpus Christi*

| | | Corpus Christi – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Acyclic Hydrocarbons | heptanes | 0.0001 | 0.0009 | 0.0017 | 0.0025 | 0.0033 | 0.0048 | 0.0057 | 0.0046 | 0.0032 | 0.0019 | 0.0006 | 0.0001 |
| | n-decane | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0004 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | 1-heptene | 0.0002 | 0.0008 | 0.0016 | 0.0026 | 0.0034 | 0.0051 | 0.0061 | 0.0050 | 0.0034 | 0.0020 | 0.0004 | 0.0001 |
| | hexane | 0.0007 | 0.0027 | 0.0044 | 0.0065 | 0.0093 | 0.0137 | 0.0160 | 0.0128 | 0.0098 | 0.0054 | 0.0019 | 0.0007 |
| | nonene | 0.0000 | 0.0002 | 0.0004 | 0.0005 | 0.0006 | 0.0008 | 0.0009 | 0.0007 | 0.0005 | 0.0003 | 0.0001 | 0.0000 |
| Alcohols | methanol | 0.0003 | 0.0009 | 0.0016 | 0.0024 | 0.0034 | 0.0050 | 0.0059 | 0.0048 | 0.0035 | 0.0020 | 0.0007 | 0.0003 |
| | ethanol | 0.0001 | 0.0005 | 0.0010 | 0.0016 | 0.0023 | 0.0035 | 0.0043 | 0.0034 | 0.0024 | 0.0013 | 0.0004 | 0.0001 |
| | isopropanol | 0.0001 | 0.0005 | 0.0010 | 0.0016 | 0.0023 | 0.0035 | 0.0042 | 0.0034 | 0.0023 | 0.0013 | 0.0003 | 0.0001 |
| | butanols (iso Butyl Alcohol) | 0.0000 | 0.0002 | 0.0003 | 0.0006 | 0.0008 | 0.0013 | 0.0016 | 0.0013 | 0.0008 | 0.0004 | 0.0001 | 0.0000 |
| | decanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | hexanol | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0004 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | 2-ethylhexanol | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Benzene/Toluene | Benzene | 0.0004 | 0.0014 | 0.0026 | 0.0041 | 0.0058 | 0.0082 | 0.0095 | 0.0077 | 0.0060 | 0.0034 | 0.0010 | 0.0003 |
| | Toluene | 0.0001 | 0.0004 | 0.0009 | 0.0014 | 0.0020 | 0.0029 | 0.0035 | 0.0028 | 0.0019 | 0.0011 | 0.0003 | 0.0000 |
| Carboxylic Acids | acetic acid | 0.0000 | 0.0002 | 0.0004 | 0.0005 | 0.0007 | 0.0012 | 0.0014 | 0.0012 | 0.0007 | 0.0004 | 0.0001 | 0.0000 |
| | propionic acid | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0004 | 0.0003 | 0.0001 | 0.0000 | 0.0000 |
| | butyric acid | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Products NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chemical Additives | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Crude Petroleum | crude oil RVP 5 | 0.0004 | 0.0018 | 0.0027 | 0.0038 | 0.0054 | 0.0079 | 0.0092 | 0.0074 | 0.0057 | 0.0031 | 0.0011 | 0.0004 |
| Distillate Fuel Oils | #1 diesel | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0006 | 0.0007 | 0.0005 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| | #2 diesel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |

| | | Corpus Christi – Empty Barges – Controlled Scenario | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Emission Factors (in pounds/bbl) in Various Months of the Year for Trip Length = 16 hours | | | | | | | | | | | |
| **WCUS Product Group** | **Specific Products** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| | marine diesel oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Gasoline | HGB Summer Gasoline RVP 5.8 | | | | | | | | | | | | |
| | HGB Winter Gasoline RVP 10.9 | | | | | | | | | | | | |
| | BPA Summer Gasoline RVP 6.1 | | | | | | | | | | | | |
| | BPA Winter Gasoline RVP 12.2 | | | | | | | | | | | | |
| | CC Summer Gasoline RVP 7.5 | | | | 0.0091 | 0.0120 | 0.0177 | 0.0212 | 0.0165 | 0.0125 | | | |
| | CC Winter Gasoline RVP 12.4 | 0.0021 | 0.0070 | 0.0117 | | | | | | | 0.0183 | 0.0051 | 0.0022 |
| Kerosene | kerosene (Fuel Oil #1) | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0005 | 0.0007 | 0.0005 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| | jet kerosene (Jet A) | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | jet naphtha (JP-4) | 0.0004 | 0.0013 | 0.0022 | 0.0032 | 0.0047 | 0.0061 | 0.0066 | 0.0055 | 0.0047 | 0.0025 | 0.0008 | 0.0002 |
| Naphtha and Solvents | Naphtha | 0.0000 | 0.0002 | 0.0004 | 0.0006 | 0.0007 | 0.0010 | 0.0011 | 0.0009 | 0.0006 | 0.0004 | 0.0001 | 0.0000 |
| | "Solvents" (JP-4) | 0.0004 | 0.0013 | 0.0022 | 0.0032 | 0.0047 | 0.0061 | 0.0066 | 0.0055 | 0.0047 | 0.0025 | 0.0008 | 0.0002 |
| Organic Compounds NEC | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Organo-Inorganic Cmpds | Assume non-volatile | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Other Hydrocarbons | Styrene | 0.0000 | 0.0001 | 0.0003 | 0.0005 | 0.0006 | 0.0010 | 0.0012 | 0.0010 | 0.0006 | 0.0003 | 0.0001 | 0.0000 |
| | Cumene | 0.0000 | 0.0001 | 0.0002 | 0.0003 | 0.0005 | 0.0007 | 0.0009 | 0.0007 | 0.0005 | 0.0002 | 0.0000 | 0.0000 |
| | MEK | 0.0003 | 0.0011 | 0.0025 | 0.0044 | 0.0054 | 0.0074 | 0.0086 | 0.0070 | 0.0053 | 0.0036 | 0.0008 | 0.0002 |
| | MTBE | 0.0019 | 0.0036 | 0.0098 | 0.0214 | 0.0252 | 0.0339 | 0.0397 | 0.0311 | 0.0250 | 0.0180 | 0.0027 | 0.0010 |
| | Butyl Acrylate | 0.0000 | 0.0001 | 0.0002 | 0.0004 | 0.0006 | 0.0009 | 0.0011 | 0.0009 | 0.0006 | 0.0003 | 0.0001 | 0.0000 |
| | Vinyl Acetate | 0.0005 | 0.0019 | 0.0034 | 0.0054 | 0.0084 | 0.0123 | 0.0142 | 0.0115 | 0.0090 | 0.0046 | 0.0013 | 0.0004 |
| | Xylene | 0.0000 | 0.0001 | 0.0003 | 0.0005 | 0.0007 | 0.0012 | 0.0014 | 0.0011 | 0.0007 | 0.0004 | 0.0001 | 0.0000 |
| | Propyl Acetate | 0.0001 | 0.0006 | 0.0013 | 0.0018 | 0.0026 | 0.0038 | 0.0046 | 0.0037 | 0.0025 | 0.0014 | 0.0004 | 0.0000 |
| | MIBK | 0.0000 | 0.0001 | 0.0003 | 0.0004 | 0.0006 | 0.0011 | 0.0013 | 0.0010 | 0.0006 | 0.0003 | 0.0001 | 0.0000 |
| Petroleum Products NEC | Lube oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Residual Fuel Oil | No. 6 Fuel Oil | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |