# Memorandum

**March 6, 2024**

**To:** **David Bruckelmeyer & Alexander Siwicki / Sheetz Inc.**

**From:** **Jaclyn Alger & Roberto Gasparini, PhD, CCM**

**RE:** **Air Emissions of Benzene from Proposed Madison Heights (Michigan) Project**

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Mr. Bruckelmeyer & Mr. Siwicki,

Spirit Environmental has been retained by Sheetz Inc. to determine the maximum potential airborne emissions of benzene from their proposed gas station in Madison Heights, Michigan. This memorandum outlines the background of this study as well as the emission calculation methodologies, operational considerations, and results.

## 1. Executive Summary

Sheetz Inc. is proposing to construct a gas station where they will sell various grades of gasoline and diesel fuel. The purpose of this air quality study is to evaluate the potential air emissions, particularly of benzene, from the proposed operations. Air emissions of benzene originate from the handling of liquid fuels at the site during three (3) key steps of their operations: filling of Underground Storage Tanks (USTs) from incoming delivery trucks, the storage of fuels in the USTs, and the refueling of customer vehicles. These steps and the emissions associated with each are summarized in Table 1.

In summary, considering all types of emissions that can be generated at the proposed site using accepted and approved emission calculation procedures, the maximum potential emissions of benzene are 0.08 pounds per hour (lb/hr) and 45.35 pounds per year (lb/yr). For context, a spill or accidental release of less than 10 lb of benzene in a day would not require any reporting to the United States Environmental Protection Agency (EPA)[i], so the EPA would not even require an amount of benzene emissions comparable to Sheetz to be reported. With respect to the annual emissions, the EPA requires that sources emitting 20,000 lb/yr or greater of benzene[ii] secure a Federal Operating Permit[iii,iv]. With maximum potential annual emissions of only 45.35 lb/day, the

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proposed gas station would not be required by the EPA to secure a Title V Federal Operating Permit. No adverse air quality impacts will be caused by the proposed Sheetz station.

**Table 1 Summary of Operations and Benzene Emissions**

| Operation | Fuel Grade | Maximum Fill Rate | Annual Throughput | Benzene Emissions | |
|---|---|---|---|---|---|
| | | gal/hr | gal/yr | lb/hr | lb/yr |
| Filling USTs | Regular 87 | 8,650 | 3,003,000 | 0.02 | 3.75 |
| | Premium 93 | | 390,000 | | 0.49 |
| | EFREE | | 39,000 | | 0.05 |
| | E85 | | 156,000 | 0.01 | 0.24 |
| UST Breathing & Emptying | Regular 87 | 2,340 | 3,003,000 | 0.01 | 12.51 |
| | Premium 93 | 1,560 | 390,000 | 0.01 | 1.63 |
| | EFREE | 780 | 39,000 | 0.003 | 0.16 |
| | E85 | 1,560 | 156,000 | 0.003 | 0.28 |
| Vehicle Refueling Operations | Regular 87 | 2,340 | 3,003,000 | 0.02 | 22.53 |
| | Premium 93 | 1,560 | 390,000 | 0.01 | 2.93 |
| | EFREE | 780 | 39,000 | 0.01 | 0.29 |
| | E85 | 1,560 | 156,000 | 0.005 | 0.50 |
| **Total from All Operations** | | | | **0.08** | **45.35** |

## 2. Proposed Operations

Liquid fuels at the proposed site consist of various grades of gasoline including Regular 87, Premium 93, Ethanol free (EFREE), 85% ethanol (E85), as well as diesel fuel. The diesel fuel that will be used at the proposed site does not have any benzene in it; therefore, we will focus on the different grades of gasoline for this study. Potential benzene emissions result from the handling of these liquid fuels during three (3) operations: the filling of the USTs, UST breathing during fuel storage and emptying, and vehicle refueling operations. Emissions from each of these operations are explained and evaluated in greater detail in the following section.

## 3. Emission Calculation Methodology

**UST Filling**

The proposed gas station will have two (2) Regular 87 USTs, one (1) Premium 93 UST, one (1) EFREE UST, and one (1) E85 UST, each at 12,000-gal capacity.

The hourly emission rates for the Regular 87, Premium 93, and EFREE USTs were calculated using EPA emission factors[v,vi]. These emission factors, which predict emissions in pounds per thousand gallons filled (lb/$10^3$ gal), are combined with the maximum fill rate of the USTs. The below considerations were considered in the emission calculations:

- The maximum hourly fill rate of each UST was limited to the capacity of the tank truck, 8,650 gal/hr.
- A single truck can fill up no more than two (2) tanks at once if they are carrying two different grades.
- The USTs were being filled entirely within one (1) hour.
- Worst-case emissions are based on two (2) USTs being continuously filled at the same time.

The hourly emission rate for the E85 UST was calculated based on the same considerations above, however a different emission factor was used[vii,viii].

The annual emission rates were calculated using the same emission factors and the projected annual throughput. The annual throughput, 3.9 million gal/yr, is the total amount of fuel the proposed site is expected to sell annually. The percentages of individual fuel grade sales were used to extrapolate the total 3.9 million gallons.

**UST Breathing and Emptying**

The EPA has identified potential emissions from UST breathing and emptying. The hourly emission rates were calculated using similar emission factors[ix]. Since UST emptying corresponds with fuel coming out of the tanks and going into vehicles, the rate of emptying was set equal to the maximum fill rate of a vehicle tank in gal/hr. The below operational considerations were employed:

- The maximum hourly fill rates of a vehicle tank are based on the maximum flow at each nozzle, 6.5 gal/min, as well as the number of nozzles and fuel type that will be pumped through each nozzle.
- Vehicle refueling was estimated to occur at most 50% of the time during an hour for a total of 30 minutes to account for the limited volume of vehicle tanks, idle time to process payment, and vehicle arrival and departure time.

The annual emissions were calculated using these same emission factors and the projected annual throughput for each fuel grade.

**Vehicle Refueling Operations**

The EPA has also identified potential emissions from spillage and displacement losses as a result of vehicle refueling, so those were also considered in this study. The hourly emission rates were calculated using the EPA emission factors[x] along with the maximum fill rate of a vehicle tank in gal/hr. The same operational considerations described above for UST breathing and emptying calculations were employed.

Similarly, the annual emissions were calculated using the same emission factors as the hourly emissions and the projected annual throughput for each fuel grade.

## 4. Speciated Benzene Emissions

The emission factors presented by EPA reflect the emissions of overall *gasoline* vapors. Benzene, however, makes up only a small fraction of the airborne emissions at a gas station. In fact, according to the Safety Data Sheets (SDSs) for fuels at the proposed gas station, benzene is at most only 1.5% of the gasoline-type fuels. Therefore, to determine benzene emissions, the subset of benzene-specific vapors was calculated[xi,xii].

Based on these calculations, the maximum possible percentage of benzene vapors is 0.42% among gasoline fuel grade vapors and 0.18% among E85 vapors.

## 5. Results and Context

Considering all emissions from the three (3) types of operations, the maximum potential emissions of benzene are 0.08 lb/hr and 45.35 lb/day. Putting these numbers into context, a spill or accidental release of less than 10 lb of benzene in a day would not require any reporting to the EPA. The maximum potential hourly emissions of 0.08 lb/hr converts to a maximum of 1.92 lb/day; therefore, the EPA would not even require it to be reported. With respect to the annual emissions, the EPA requires that sources emitting 10 tpy or greater of benzene secure a Federal Operating Permit. With maximum potential annual emissions of only 45.35 lb/day, which converts to 0.02 tpy, the proposed gas station would not be required by the EPA to secure a Title V Federal Operating Permit.

## 6. Conclusion

In conclusion, considering all of the operations at absolute maximum levels, no adverse air quality impacts will be caused by the proposed Sheetz gas station in Madison Heights, Michigan.

For Spirit Environmental, LLC,

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[i] The EPA has a list of Reportable Quantities (RQ) of hazardous substances that requires sites to report any unauthorized emissions in excess of the chemical's RQ. The RQ for benzene is 10 lb/day. EPA List of RQs, https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-117/subpart-A/section-117.3

[ii] EPA List of HAPs, https://www.epa.gov/haps/initial-list-hazardous-air-pollutants-modifications

[iii] A Federal Operating Permit is a legally enforceable document designed to improve compliance by clarifying what facilities (sources) must do to control air pollution as required by Title V of the Clean Air Act. https://www.epa.gov/title-v-operating-permits/basic-information-about-operating-permits#:~:text=Legally%2Denforceable%20documents%20designed%20to,of%20the%20Clean%20Air%20Act.

[iv] Title V Permit Thresholds, https://www.epa.gov/title-v-operating-permits/who-has-obtain-title-v-permit

[v] The EPA has published a Compilation of Air Pollutant Emissions Factors (AP-42) that includes emission factors associated with various industrial operations, among which is the transportation and marketing of petroleum liquids, based on historical air quality studies.

[vi] The filling of the Regular 87, Premium 93, and EFREE USTs use a balanced submerged filling method, which reduces evaporative emissions involved in this process as vapors generated inside the UST during filling are routed back to the truck. Therefore, the emission factor for balanced submerged filling in Table 5.2-7 was used in this calculation.

[vii] The emission factors presented by the EPA reflect the emissions of gasoline vapors. At 85% ethanol, the E85 fuel characteristically behaves less like gasoline because it is only comprised of 15% gasoline. Therefore, the emission factor was determined using the loading loss equation in AP-42, Section 5.2, which is then used to calculate emissions from loading E85. This equation incorporates the true vapor pressure, molecular weight, and temperature of the site-specific situation, which results in a more accurate emission factor reflecting a blend that is primarily ethanol.

[viii] Loading Loss Equation (1), https://www3.epa.gov/ttn/chief/ap42/ch05/final/c05s02.pdf

[ix] Emission factor for underground tank breathing and emptying in lb/$10^3$gal in AP-42 Chapter 5, Table 5.2-7, AP-42 Section 5.2: Transportation And Marketing Of Petroleum Liquids (epa.gov)

[x] Emission factor for controlled displacement losses and spillage in lb/$10^3$gal in AP-42 Chapter 5, Table 5.2-7, AP-42 Section 5.2: Transportation And Marketing Of Petroleum Liquids (epa.gov)

[xi] The total gasoline emissions from each of the three (3) operations were speciated by applying Raoult's Law – a principle of physical chemistry that can be used to distinguish individual species within a mixture – to calculate the contribution of benzene to the total emissions. Raoult's Law uses the liquid weight fraction, the calculated true vapor pressure, and various chemical properties of gasoline and benzene to calculate the partial pressures. Since partial pressures are a function of temperature, the partial pressures were calculated at different temperatures spanning expected ambient atmospheric conditions (40ºF-100ºF) to determine the highest possible percentage of benzene in the gasoline vapors for worst-case emissions. The partial pressures were then used to calculate the vapor weight fraction of each compound. An additional Raoult's Law calculation was performed for the E85 fuel based on the chemical properties of ethanol, gasoline, and benzene.

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[xii] True vapor pressure is calculated using AP-42 Chapter 7, Antoine's equation (equation 1-26), https://www.epa.gov/sites/default/files/2020-10/documents/ch07s01.pdf and the vapor weight fractions were calculated using AP-42, Chapter 7, Section 7.1.4, Equations 40-5 and 40-6, https://www3.epa.gov/ttnchie1/ap42/ch07/final/ch07s01.pdf.