REFINED HAZARD

CARCINOGENIC AIR POLLUTION FROM AMERICA'S OIL REFINERIES

October 1, 2008

Petroleum refineries are a major source of pollution in the United States, releasing a significant amount of carcinogenic pollutants into the air Americans breathe. Although petroleum refineries are the backbone of America's oil-based economy, the pollution released from refineries can pose a serious risk of harm to human health. In this report, we use data from the U.S. Environmental Protection Agency's ("EPA") Toxics Release Inventory ("TRI") to catalogue refinery air emissions of certain pollutants that are known or suspected to cause cancer. The TRI, established under the Emergency Planning and Community Right-to-Know Act of 1986 ("EPCRA"), is an EPA database that contains information on toxic chemical releases reported annually by certain covered industries, including petroleum refineries.

According to information reported to the TRI, emissions of carcinogens[1] from U.S. refineries actually *increased* between 2004 and 2006. This represents a disturbing shift from an industry-wide decline in carcinogenic emissions from U.S. refineries in previous years.[2] In 2006, a handful of refineries accounted for approximately 36% of total emissions of carcinogens. The top ten largest emitters, in terms of total emissions of carcinogens reported,[3] are:

1. **BP: Texas City, TX**
2. **Exxon Mobil: Baytown, TX**
3. **Citgo: Lake Charles, LA**
4. **Houston Refining Co.: Houston, TX**
5. **Flint Hills Res: Corpus Christi, TX**
6. **Motiva: Port Arthur, TX**
7. **Chalmette Refining: Chalmette, LA**
8. **Conoco Phillips: Sweeny, TX**
9. **Conoco Phillips: Roxana, IL**
10. **Valero: Corpus Christi, TX**

The biggest polluters, however, are not always the largest refineries. Our review revealed that some facilities emit much more carcinogens per barrel of oil produced than others. Interestingly, Texas refineries report more than eight times more carcinogens emitted per barrel of oil than California refineries.

[1] The Occupational Health and Safety Administration ("OSHA") has created a list of chemicals it considers carcinogenic, many of which oil refineries emit in large quantities. These chemicals are called "OSHA Carcinogens." The use of the term "carcinogen" in this report refers to "OSHA Carcinogens."
[2] *See* Envtl. Integrity Project, Refined Hazard: Carcinogenic Air Pollution from America's Oil Refineries (Aug. 2007) (noting an overall industry-wide decline in carcinogenic releases from U.S. refineries between 1999 and 2004).
[3] *See infra* Table 1. A discussion of the methodology used in compiling the information contained in this report follows the presentation of the results of our study.

The top ten emitters, in terms of carcinogens released per barrel of oil produced,[4] are:

1. Calumet Lubricants: Cotton Valley, LA	**2. BP: Texas City, TX**
3. Giant Refining: Gallup, NM	**4. Total Petrochemicals: Port Arthur, TX**
5. NCRA: McPherson, KS	**6. Sinclair Oil: Sinclair, WY**
7. Valero: Corpus Christi, TX	**8. Alon USA: Big Spring, TX**
9. Chalmette Refining: Chalmette, LA	**10. Shell Oil: Yabucoa, PR**

There may be a silver lining when it comes to emission trends. Overall, refinery emissions of hazardous air pollutants—a broader category that includes both carcinogens and pollutants that are harmful in other ways—declined between 2004 and 2006 by slightly more than 9%.

On the other hand, there is troubling evidence that refinery emissions may be significantly underreported. For example, only six of the nation's 150[5] refineries reported releasing a total of 142,995 pounds of formaldehyde in 2005. But according to the methods EPA has developed for measuring formaldehyde released from refining processes, industry-wide emissions could exceed 4 million pounds a year. In addition, new "remote sensing" technologies that directly measure air emissions show that refinery releases of carcinogens can be as much as *100 times* higher than industry estimates that are based on outdated EPA emission factors. The city of Houston filed a petition on July 10, 2008, asking EPA to replace outdated and inaccurate emission factors that are used to estimate refinery emissions with newer and more accurate methods of measurement.[6]

Results

I. <u>OSHA Carcinogens</u>

The TRI "OSHA Carcinogens" are chemicals that are carcinogenic or potentially carcinogenic according to standards set out in the OSHA "Hazard Communication Standard."[7] Designations of chemicals as carcinogenic, or possibly carcinogenic, in humans are made by expert consensus groups established by the U.S. National Toxicology Program ("NTP"), or by the International Agency for Research on Cancer ("IARC"), an agency of the World Health Organization. The TRI "OSHA Carcinogens" emitted by refineries may include benzene, ethylbenzene, butadiene, polycyclic aromatic hydrocarbons ("PAHs"), naphthalene, formaldehyde, and metals such as nickel and lead.

---

[4] *See infra* Table 2.

[5] U.S. Energy Info. Admin., Number and Capacity of Operable Petroleum Refineries by PAD District and State as of January 1, 2008, http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/refinery_capacity_data/current/table1.pdf.

[6] You can view the City of Houston's petition at http://www.environmentalintegrity.org/pub522.cfm.

[7] U.S. Envtl. Prot. Agency, Toxics Release Inventory (TRI) Program: OSHA Carcinogens, http://www.epa.gov/tri/chemical/OSHA/oshacarc.htm.

Our study of the TRI data concerning releases of OSHA Carcinogens by U.S. refineries in 2004 and 2006 revealed the following points:

- **Total OSHA Carcinogens *increased* slightly from 3,090,521 in 2004 to 3,164,460 in 2006, an increase of about 74,000 lbs, or a little more than 2%.**
- **The biggest sources of OSHA carcinogens in 2006 (counting both fugitive and point source emissions) were:**

Table 1

Refinery	Total OSHA Carcinogen Emissions (lbs/year)	Refinery Capacity (barrels of oil / day)	Emissions per Thousand Barrels of Oil Production Capacity (lbs / 1000 barrels)
BP in Texas City, TX	181,352	205,000	2.40
Exxon Mobil in Baytown, TX	141,310	562,500	.70
Citgo in Lake Charles, LA	136,840	429,500	.90
Houston Refining Co., in Houston, TX	118,976	270,200	1.20
Flint Hills Resources in Corpus Christi, TX	118,422	288,126	1.13
Motiva in Port Arthur, TX	98,889	285,000	.95
Chalmette Refining in Chalmette, LA	97,986	192,760	1.39
Conoco Phillips in Sweeny, TX	79,300	247,000	.90
Conoco Phillips in Roxana, IL	79,009	306,000	.71
Valero in Corpus Christi	74,933	142,000	1.45

These ten refineries account for 16% of the total refining capacity in the U.S., but emit 36% of the OSHA Carcinogens. These refineries are larger than average, but that fact alone does not explain why their emissions are so much higher. The average U.S. refinery emits approximately 0.52 lbs of OSHA Carcinogens per 1,000 barrels of oil. As Table 1 indicates, all ten refineries above release more carcinogens per barrel of oil refined than the industry-wide average. One note of caution: TRI emission reports from several large facilities may include emissions from chemical production units located adjacent to the refinery, which may complicate "pound per barrel" comparisons.

Three of the largest emitters—BP in Texas City, Exxon Mobil in Baytown, and Valero in Corpus Christi—reported significant decreases in emissions of carcinogens between 2004 and 2006. Five others—Citgo in Lake Charles, Motiva in Port Arthur, Chalmette Refining and the two Conoco Phillips refineries—reported significant increases over the same two year period. Emissions of carcinogens from the Citgo Lake Charles refinery jumped from 83,347 lbs in 2004 to 136,840 lbs in 2006, continuing a long-term trend.

- **The biggest refineries are not necessarily emitting the most OSHA Carcinogens, both in terms of gross pounds of emissions and in terms of emissions per barrel of oil. Some of the smaller refineries pack a big punch. The refineries that emit the most OSHA Carcinogens per barrel of oil are:**

Table 2

Refinery	Refinery Capacity (barrels of oil / day) *Capacity of an average US Refinery is 119,000	Emissions per Thousand Barrels of Oil Production Capacity (lbs/ 1000 barrels of oil) *Emission rate of an average US Refinery is 0.52lbs/1000 barrels
Calumet Lubricants in Cotton Valley, LA	13,020	2.68
BP in Texas City, TX	205,000	2.40
Giant Refining in Gallup, NM	20,800	2.29
Total Petrochemicals in Port Arthur, TX	95,500	1.92
NCRA in McPherson, KS	81,200	1.74
Sinclair Oil in Sinclair, WY	66,000	1.47
Valero in Corpus Christi, TX	142,000	1.45
Alon USA in Big Spring, TX	67,000	1.37
Chalmette Refining in Chalmette, LA	192,760	1.39
Shell Oil in Yabucoa, PR	77,900	1.32
Sinclair Oil in Tulsa, OK	70,300	1.30

- **The refineries that emit the least OSHA Carcinogens per barrel of oil are:**

Table 3

Refinery	Refinery Capacity (barrels of oil/day) *Capacity of an average US Refinery is 119,000	Emissions per Thousand Barrels of Oil Production Capacity (lbs/ 1000 barrels of oil) *Emission rate of an average US Refinery is 0.52lbs/1000 barrels
San Joaquin Refining in Bakersfield, CA*	15,000	.005
Petro Star in North Pole, AK	17,500	.008
Petro Star in Valdez, AK	48,000	.011
Chevron in Perth Amboy, NJ	80,000	.027
Ergon Refining in Vicksburg, MS	23,000	.031
Ultramar in Wilmington, CA	80,887	.039
Chevron in El Segundo, CA	260,000	.046
Lunday Thagard in South Gate, CA	8,500	.051
BP West Coast in Los Angeles, CA	265,000	.054
Shell Oil in Anacortes, WA	145,000	.067
ConocoPhillips in Arroyo Grande, CA	44,200	.071
Valero in Wilmington, CA	6,300	.073
Big West of California in Bakersfield, CA	66,000	.073
Suncor in Commerce City, CO	62,000	.077

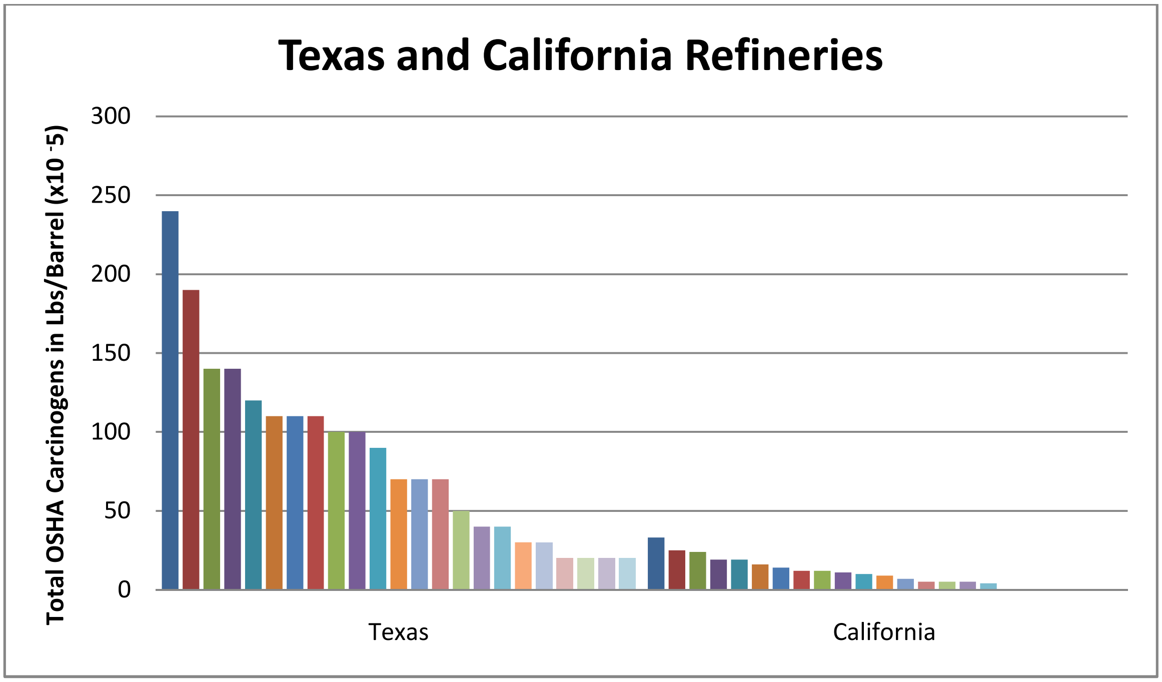
*Note that San Joaquin is classified as an oil refinery by the Energy Information Association and its SIC code is 2911 (Petroleum Refining), but it does not produce gasoline, which may be a reason for its low emission rates.

Three refineries that report the highest total releases of OSHA carcinogens—BP Texas City, Chalmette Refining, and Valero in Corpus Christi—are also three of the ten worst emitters of OSHA Carcinogens per barrel of oil. BP reported emitting 181,352 lbs of OSHA Carcinogens from their Texas City refinery in 2006. With a refinery capacity of 205,000 barrels of oil per calendar day, BP emits 2.40 lbs of OSHA Carcinogens per 1,000 barrels of oil. This is 4.6 times more than the national average and 240 times more than the best U.S. refineries, which emit only .005 lbs of OSHA Carcinogens per 1,000 barrels of oil. Chalmette in Louisiana and Valero in Corpus Christi both emit about 2.7 times more OSHA Carcinogens per barrel of oil than the national average, and 140 times more than the best refineries.

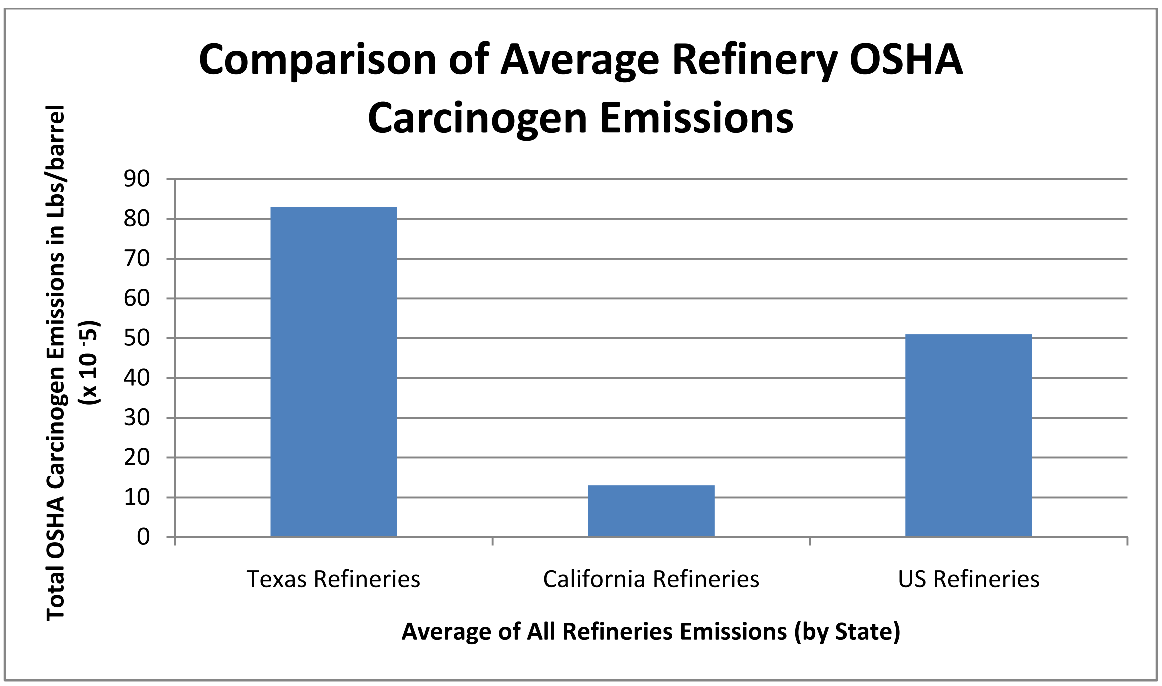
But measured on a per barrel basis, several other very large refineries report only minimal emissions of OSHA carcinogens, while other smaller refineries release significantly more relative to their levels of production. For example:

- BP in Los Angeles, CA is a relatively large 265,000 barrel per day refinery that emitted 5,220 lbs of OSHA Carcinogens in 2006. That amounts to .054 lbs of OSHA Carcinogens per 1,000 barrels of oil.
- Chevron in El Segundo, CA has a capacity of 260,000 barrels per day and emitted 4,325 lbs of OSHA Carcinogens in 2006, at a rate of .046 lbs per 1,000 barrels.
- By contrast, Calumet Lubricants in Cotton Valley, LA is a small refinery with the capacity to process 13,020 barrels of oil per day. In 2006, it emitted 12,714 lbs of OSHA Carcinogens, which amounts to 2.68 lbs of OSHA Carcinogens per 1,000 barrels.
- Giant Refining, another small refinery with the capacity to process 20,800 barrels of oil per day, emitted 17,296 lbs of OSHA Carcinogens in 2006. Giant put out OSHA Carcinogens at a rate of 2.29 lbs per 1,000 barrels.
- Both of these small refineries exceed the much larger BP, Chevron, and Motiva refineries in both gross pounds of OSHA Carcinogen emissions and in the rate of emissions per barrel.

- **There is a notable difference in the rate of OSHA Carcinogen emissions from refineries in Texas and California.**
  - Texas provides 24% of the nation's refining capacity and 39% of the total OSHA Carcinogen emissions, with an average rate of OSHA Carcinogen emissions of .84 lbs per 1,000 barrels of oil.
  - California provides 11% of the nation's refining capacity and 3% of the total OSHA Carcinogen emissions, with an average rate of OSHA Carcinogen emissions of .13 lbs per 1,000 barrels of oil.



- On average, Texas refineries emit 1.6 times more per barrel than the average U.S refinery and 8 times more per barrel than the average California refinery.



- **Why is there such a large difference in carcinogen emissions from refineries in Texas and California?**

Carcinogen releases at refineries can be impacted by a variety of factors. For example, the frequency of maintenance of storage tanks and other refinery equipment can significantly influence the amount of carcinogens released at a refinery.[8] A storage tank that has broken seals or loose fittings will release more carcinogens than a storage tank that is properly maintained.[9] Although there are several potential explanations for the large difference in emission rates from refineries in Texas and California, two appear to be particularly relevant:

Refinery Design May Impact Carcinogen Emissions. Refinery processes can vary greatly from one facility to another depending upon the type of end product produced. Petroleum refineries provide the fuel we use for transportation, manufacturing and home heating, and produce the "building blocks" chemicals used to make plastics and other important products used in the home and business. As such, not all refineries are designed the same because they produce different products.

Industry argues that a refinery's design, its complexity, production processes, and feedstock, all have the potential to impact the type and amount of carcinogens released.[10] For example, industry asserts that very few refineries in California have aromatic hydrocarbon production units, whereas the majority of Texas refineries do.[11] Benzene is an aromatic hydrocarbon. Industry argues that because most California refineries do not produce aromatics, California refineries will emit fewer carcinogens like benzene than Texas refineries.[12]

California Refineries Must Comply With Strict Pollution Control Laws. Another possible explanation for the large differences in emission rates between Texas and California refineries is that California law requires refineries to install better pollution control technology to reduce the carcinogen emissions released.

Local air quality regulations set forth by the South Coast Air Quality Management District (SCAQMD) significantly restrict emissions from California refineries located in Southern California.[13] The SCAQMD regulations are more stringent than the state regulations that Texas refineries must follow.[14] This increased regulation might explain why two refineries, owned by the same company and similar in profile, Valero in Wilmington CA and Valero in Corpus Christi TX, report significantly different emissions.

---

[8] Texas Industry Letter, at 2.
[9] *Id.*
[10] *Id.* at 2-3.
[11] *Id.* at 2.
[12] *Id.*
[13] For example, Texas leak detection and repair regulations have a higher leak detection threshold for volatile organic compounds, which include OSHA carcinogens like benzene, and allow refineries a longer time period to repair these leaks than California rules. *Compare* 30 Tex. Admin. Code § 115.352 *with* South Coast Air Quality Management District Rule 1173, *available at* http://www.aqmd.gov/rules/rulesreg.html. In addition, unlike Texas, the SCAQMD can take enforcement action against refineries for leaks above the detection threshold. *Id.*
[14] *Id.*

II. Unreported and Inaccurate Emissions Data

Emissions of carcinogens from many refineries are likely to be much greater than what is reflected in the TRI data analyzed for this report due to unreported and inaccurate emissions data. For example, our review revealed that the majority of U.S. refineries do not report releases of formaldehyde. Emissions of other carcinogens, like benzene, are likely significantly under-counted by refineries, because they are based on equations—called "emissions factors"—that significantly underestimate air pollution. Actual monitoring often shows much higher levels of pollution than estimates based on emission factors.

A. Millions of Pounds of Formaldehyde Emissions May Be Un-reported by U.S. Refineries

Petroleum refineries reported emitting a total of 142,995 pounds of formaldehyde in 2005. Only *six* out of the nation's 150 refineries reported *any* formaldehyde releases to TRI. We estimated emissions from refineries based on EPA emission factors and data from the U.S. Energy Information Administration ("EIA") regarding refinery inputs.[15] Our analysis suggests that refineries emitted *4,308,029 to 9,555,805 million* pounds of formaldehyde, as opposed to the 142,995 reported by industry in 2005. Although refineries are not required to report *de minimis* releases (0.10) of formaldehyde,[16] this hardly explains the millions of pounds of unaccounted formaldehyde emissions from refineries.

B. EPA Emission Factors May Drastically Under-count Emissions of Carcinogens Like Benzene

U.S. refineries reported releasing 1,791,273 pounds of benzene in 2006 based on calculations using emission factors that significantly undercount emissions. While this amount is significant, total emissions of benzene released from U.S. refineries are likely to be much higher than the TRI data suggest, and suggest that the health impacts from refineries are likely much more serious than previously stated.

Refineries use mathematical equations called emission factors that are developed by EPA to estimate emissions of carcinogens. EPA and scientists agree that the current emission factors likely significantly underestimate actual emissions of carcinogens from refineries.[17] A recent EPA technical memorandum cited numerous studies that demonstrate gross inaccuracies in emissions data for refineries that are the result of poor quality emission factors.[18] A 2006 study by the Alberta Research Council using remote sensing technologies to measure actual emissions show that benzene releases from petroleum

[15] *See* Methodology and Background section *infra*.
[16] U.S. Envtl. Prot. Agency, EPCRA Section 313 Chemical List for Reporting Year 2005, http://www.epa.gov/tri/chemical/chemical%20lists/RY2005ChemicalLists.pdf.
[S]*ee, e.g.*, Memorandum from Brenda Shine, U.S. Envtl. Prot. Agency, on Potential Low Bias of Reported VOC Emissions from the Petroleum Refining Industry to EPA Docket No. EPA-HQ-OAR-2003-0146 (July 27, 2007) [hereinafter EPA, Potential Low Bias] *and* Allan Chambers, et al., Alberta Research Council, *Refinery Demonstration of Optical Technologies for Measurement of Fugitive Emissions and for Leak Detection* 17–18 (Mar. 31, 2006).
[18]EPA, Potential Low Bias.

storage tanks can be 100 times greater than estimates based on EPA emission factors.[19] The city of Houston filed a petition on July 10, 2008, asking EPA to replace inaccurate emission factors with newer and more accurate methods of measurement.[20]

Methodology and Background

I. Toxics Release Inventory

The Toxics Release Inventory ("TRI"), established under the Emergency Planning and Community Right-to-Know Act of 1986 ("EPCRA") and expanded by the Pollution Prevention Act of 1990 ("PPA"), is an on-line publicly available EPA database that contains information on toxic chemical releases reported annually by certain covered industries, including petroleum refineries. Reporting is required for several dozen carcinogenic chemicals, some of which have been shown to cause cancer in people, and some of which cause cancer in animals and may be carcinogenic to people. Looking at releases of the group of chemicals that TRI refers to as "OSHA carcinogens" as a whole, a picture emerges of the extent to which certain petroleum refineries, as well as the refining industry as a whole, are releasing carcinogens.

We searched the TRI for data on air releases of carcinogenic chemicals in 2006. Although TRI divides air emissions into "fugitive" and "stack" (or "point source") emissions, we also totaled the fugitive and stack data in order to consider "total air emissions" for our analyses. In addition, we focused on the amount of carcinogenic chemicals released per barrel of oil processed.

Further, this report analyzes carcinogenic air emissions in three distinct groupings. First, we consider emissions of "OSHA carcinogens," which are TRI chemicals that are likely to be classified as carcinogens under the requirements of OSHA, and are listed in the on-line EPA document "Toxics Release Inventory (TRI) Basis of OSHA Carcinogens." Although TRI is an EPA database, EPA's own carcinogenicity designations do not appear to be used for compiling the TRI "OSHA carcinogen" list.

II. The TRI "OSHA Carcinogen" List

The TRI "OSHA Carcinogens" are chemicals that are carcinogenic or potentially carcinogenic according to standards set out in the OSHA "Hazard Communication Standard."[21] Designations of chemicals as carcinogenic, or possibly carcinogenic, to humans are made by expert consensus groups established by an agency of the U.S. Government (the National Toxicology Program ("NTP")) or by the International Agency for Research on Cancer ("IARC"), an agency of the World Health Organization. Under the TRI program, the *de minimus* limit for OSHA carcinogens is 0.1 percent, which means

[19] *See, e.g.*, Allan Chambers, et al., Alberta Research Council, Refinery Demonstration of Optical Technologies for Measurement of Fugitive Emissions and for Leak Detection 17–18 (Mar. 31, 2006).
[20] You can view the City of Houston's petition at http://www.environmentalintegrity.org/pub522.cfm.
[21] U.S. Envtl. Prot. Agency, Toxics Release Inventory (TRI) Program: OSHA Carcinogens, http://www.epa.gov/tri/chemical/OSHA/oshacarc.htm.

OSHA carcinogens present in a mixture above 0.1 percent must be reported. The *de minimus* limitation for chemicals that are *not* OSHA carcinogens is 1.0 percent.

III. Fugitive Versus Stack (Point Source) Emissions

TRI reports air releases as either "fugitive" or "stack" ("point source") emissions. Stack releases come from structures designed to release process wastes of various types, including combustion gases, side-products or other contaminants of industrial processes. Fugitive emissions can occur from any non-stack source of releases at a facility, including storage tanks, broken pipes, or leaking flanges. Fugitive emissions offer insight into the state of maintenance and repair (or disrepair) at facilities, while stack emissions reflect the effectiveness (or lack thereof) of pollution control devices installed in or near a stack and the types of processes going on at a facility.

A. Fugitive Emissions

Petroleum refineries are sprawling industrial facilities, with pipes, storage containers, distilling/fractionation columns and related process machinery, and other equipment spread over several acres. When chemicals are released from any point in a refinery other than a stack, the release is a "fugitive emission."

Fugitive emissions often come from flanges, broken piping, leaking equipment used to store feedstock or chemicals (including products such as gasoline), or process upsets. The result of an upset can be as small as a minor leak due to an unforeseen change in pressure in piping, or as large as a catastrophic explosion.

Fugitive emissions can be especially hazardous for workers, and could be hazardous for community residents near the fenceline of a refinery. The unpredictability of fugitive emissions is what makes them especially worrisome. Also, unlike stacks, the myriad points at a refinery where process equipment could fail are unlikely to have emission control or monitoring devices.

The extent to which there are fugitive emissions at an industrial facility is directly related to maintenance of process equipment and housekeeping at the facility. If preventive maintenance is insufficient and housekeeping is poor, then the likelihood of fugitive emissions increases. Refineries tend to run at or close to their full production capacity, and shutting down part of a refinery for preventive maintenance is something that facility owners tend to avoid. Questions about adequacy of preventive maintenance and housekeeping have been raised after catastrophes such as the explosion and fire at the BP Texas City refinery in 2005 that killed fifteen people.

B. Stack Emissions

When people think of "stacks," they often think only of the very large smokestacks associated with power plants. However, industrial facilities often have process-related stacks which vent process waste products of various types. Stacks may have emission control devices within them, as well as pollutant monitoring devices that check for the presence of certain pollutants.

High releases from stacks, as opposed to fugitive emissions, can indicate something wrong with a pollution control device in the stack, or some process failure resulting in release through the stack of an unanticipated type or amount of pollutant. Releases from stacks are usually more predictable than fugitive emissions, but process upsets or equipment failure can cause releases through the stack whose nature or quantity can present serious problems.

IV. Data on Production Capacity for Petroleum Refineries

We used reports from the U.S. Energy Information Administration ("EIA"), an agency within the U.S. Department of Energy, for information on production capacity of petroleum refineries in the fifty United States and in the Virgin Islands and Puerto Rico. The "Capacity of Operable Petroleum Refineries by State as of January 1, 2005" was the set of capacity numbers we used for 2004. The "Capacity of Operable Petroleum Refineries by State as of January 1, 2007" was the set of capacity numbers we used for 2006.[22] We used the data collected by EIA for "operating" capacity for "atmospheric crude oil distillation" to determine production in barrels per day ("bpd") of crude petroleum.

V. Emission Factors

Emission factors are equations used to estimate emissions from sources of air pollution. We estimated emissions from refineries based on EPA emission factors and data from the EIA regarding refinery inputs to generate data in section III.A. For example, EPA's published emission factor for fluid catalytic cracking units ("FCCUs") is 4.86 pounds of formaldehyde per thousand barrels of fresh feed. To obtain annual estimates of formaldehyde emissions from this process, we multiplied the emission factor by the total number of barrels (in thousands) of fresh feed used by all refinery FCCUs in each study year, as reported by the EIA.

To obtain EPA emission factors, we used the EPA's on-line database of emission factors, the "Factor Information Retrieval System" ("WebFIRE"),[23] to identify the Petroleum Industry Formaldehyde Emission Factors for Fluid Catalytic Cracking Units (4.860E0 lbs. per 1,000 barrels ("bbl") fresh feed processed); Thermal Catalytic Cracking Units (2.200E0 lbs. per 1,000 bbl. fresh feed processed); and Fluid Coking Units (1.190E0 lbs. per 1,000 bbl. fresh feed processed). However, because the EIA's fresh feed data does not differentiate between "thermal" and "fluid" catalytic crackers (indicating only "catalytic cracking units"), we applied the lower emission factor— 2.200E0 lbs. per 1,000

[22] U.S. Energy Info. Admin., Capacity of Operable Petroleum Refineries by State as of January 1, 2007, *available at* http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/refinery_capacity_data/historical/2007/table3.pdf.
[23] U.S. Envtl. Prot. Agency, Technology Transfer Network, Clearinghouse for Inventories & Emission Factors, Emission Factors & AP 42, http://www.epa.gov/ttn/chief/index.html.

bbl. fresh feed processed applicable to thermal catalytic crackers—to all "catalytic cracking unit" fresh feed data.

We also identified a range of Petroleum Industry Formaldehyde Emission Factors for heaters and boilers: External Combustion Boilers (6.280E-5 lbs. per million British thermal units ("mm Btu") of heat input); Process Heaters (uncontrolled) (5.470E-5 lbs. per mm Btu of heat input; Incinerators (3.930E-5 lbs. per mm Btu of heat input); and Process Heaters (Low NOx Burners) (8.800E-7 lbs. per mm Btu of heat input). Thus, the emission factors for heaters and boilers range from 8.800E-7 lbs. per mm Btu to 6.280E-5 lbs. per mm Btu. In order to calculate formaldehyde emissions due to the combustion of "still gas" and/or "natural gas" (as reported by the EIA) we calculated the Btu from the combustion of those gases, assumed that such gas was used to operate heaters and/or boilers, and applied the highest and lowest emission factors from heaters and boilers in order to present a possible range of formaldehyde emissions from gas combustion. Those ranges are presented in the attached inventory. However, for the purposes of this narrative report, we have applied the lowest possible emission factor (*i.e.*, 8.800E-7 lbs. per mm Btu).

The input data was obtained from EIA reports of "Downstream Processing of Fresh Feed Input,"[24] "Downstream Charge Capacity of Operable Petroleum Refineries,"[25] and "Fuel Consumed at Refineries."[26]

VI. Limitations on Data

A. Changes in Facility Ownership

Our study surveyed carcinogen releases from petroleum refineries during the period 2004–2006. During that period, there were numerous changes in ownership of refineries in our study group. In fact, there were purchases of facilities by companies that then sold the facilities again or changed their corporate names.

Although the fluidity of ownership of some of the refineries presented some difficulty in tracking ownership, we used EIA reports, information obtained on-line and other resources to do so.

B. EIA and TRI Do Not Use Identical Names for Individual Refineries

EIA and TRI do not necessarily use the same names for facilities in the group of petroleum refineries covered in this report. This sometimes made it difficult to attribute production capacity to certain facilities for which we had data on carcinogen releases.

For example, three refineries in Corpus Christi, Texas, actually have two facilities each— an "east plant" and a "west plant." While TRI has reports filed for each facility

[24] *See* http://tonto.eia.doe.gov/dnav/pet/pet_pnp_dwns_dc_nus_mbblpd_m.htm.
[25] *See* http://tonto.eia.doe.gov/dnav/pet/pet_pnp_dwns_dc_nus_a.htm.
[26] *Id.*

separately (*e.g.*, "Valero Corpus Christi East plant" and "Valero Corpus Christi West plant"), EIA groups the plants together under one corporate name and city (*e.g.*, "Valero Corpus Christi").

When we had emission data for individual chemicals from, for example, one or both of the Valero Corpus Christi facilities, and we had only one production capacity estimate—for Valero Corpus Christi as a whole, if both facilities appeared on one set of our "top 10" lists (as, hypothetically, fugitive and stack emissions for benzene in 2002)—we counted capacity from Valero Corpus Christi only once to avoid over-counting.

In addition, EIA and TRI sometimes use different geographic descriptors for refineries, as in the case of a group of refineries in New Mexico where EIA consolidated two refineries owned by one company and used different town names for the refinery locations than did TRI, which kept the facilities separate. We made every effort to detect and reconcile such discrepancies.

C. "Operating" Versus "Idle" Production Capacity

In some cases, EIA indicated zero ("0") "operating" production capacity for a facility for a reporting year. Although a "bpd" value was usually given for "idle" production capacity in those cases, we cannot tell how much crude oil the refinery was actually processing on any given day during the reporting year. Therefore, we noted that facility's production capacity as zero, although emissions from the facility were included in our analyses.

D. Carcinogens Can be Released from Petroleum Refineries in Media Other than Air, the Medium Considered in this Report

This report considered only air releases of carcinogens from petroleum refineries. Although air pollution associated with refineries, especially in terms of possible health hazards to people living near the refinery fence line, is of great importance, carcinogens can be released from refineries into water or onto land.

Hurricanes Katrina and Rita illustrated the potential for the release of pollution from petroleum refineries through media other than air. For instance, the Murphy refinery in Meraux, Louisiana was flooded during Hurricane Katrina. Hazardous chemicals from the refinery were detected in neighboring areas, with both liquids and sludge identified as means by which pollutants moved from the facility.

TRI data include releases through water and land, and such data could be used to gain further insight into the release of carcinogens from petroleum refineries.