Hazardous Substance Research Center South & Southwest

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Environmental Impact of the Petroleum Industry

Petroleum refining is one of the largest industries in the United States and a vital part of the national economy. However, potential environmental hazards associated with refineries have caused increased concern for communities in close proximity to them. This update provides a general overview of the processes involved and some of the potential environmental hazards associated with petroleum refineries.

Definition of a petroleum refinery

Petroleum refineries separate crude oil into a wide array of petroleum products through a series of physical and chemical separation techniques. These techniques include fractionation, cracking, hydrotreating, combination/blending processes, and manufacturing and transport. The refining industry supplies several widely used everyday products including petroleum gas, kerosene, diesel fuel, motor oil, asphalt, and waxes.

Background

The United States is one of largest producers and consumers of crude oil in the world. Based on data from the U.S. Department of Energy (1998), in 1995 the United States was responsible for about 23% of the worlds' refinery production. With a record high of 324 refineries in the early 80's, the U.S. was able to produce about 18.6 million barrels per day. However, because of changes in oil prices, a shift to alternate fuel use and an increasing focus on conservation, by 1985 the industry lost several primarily small, inefficient refineries that could not continue to compete. Over the last decade, the number of refineries has continued to shrink from about 194 to the current 155. This decrease has been due in part to increasing requirements placed on the facilities for producing cleaner fuels along with a number of mandated federal and state clean air and water regulations.

Processes involved in refining crude oil

The process of oil refining involves a series of steps that includes separation and blending of petroleum products. The five major processes are briefly described below:

• *Separation processes*: These processes involve separating the different fractions/ hydrocarbon compounds that make up crude oil based on their boiling point differences. Crude oil generally is composed of the entire range of components that make up gasoline, diesel, oils and waxes. Separation is commonly achieved by using atmospheric and vacuum distillation. Additional processing of these fractions is usually needed to produce final products to be sold within the market.

• *Conversion processes*: Cracking, reforming, coking, and visbreaking are conversion processes used to break down large longer chain molecules into smaller ones by heating or using catalysts. These processes

allow refineries to break down the heavier oil fractions into other light fractions to increase the fraction of higher demand components such as gasoline, diesel fuels or whatever may be more useful at the time.

• *Treating*: Petroleum-treating processes are used to separate the undesirable components and impurities such as sulfur, nitrogen and heavy metals from the products. This involves processes such as hydrotreating, deasphalting, acid gas removal, desalting, hydrodesulfurization, and sweetening.

• *Blending/combination processes*: Refineries use blending/combination processes to create mixtures with the various petroleum fractions to produce a desired final product. An example of this step would be to combine different mixtures of hydrocarbon chains to produce lubricating oils, asphalt, or gasoline with different octane ratings.

• *Auxiliary processes*: Refineries also have other processes and units that are vital to operations by providing power, waste treatment and other utility services. Products from these facilities are usually recycled and used in other processes within the refinery and are also important in regards to minimizing water and air pollution. A few of these units are boilers, wastewater treatment, and cooling towers.

Environmental hazards of petroleum refineries

Refineries are generally considered a major source of pollutants in areas where they are located and are regulated by a number of environmental laws related to air, land and water. Some of the regulations that affect the refining industry include the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act, CERCLA (i.e. Superfund: Comprehensive Environmental Response, Compensation, and Liability Act), Emergency Planning and Community Right-to-Know (EPCRA), OSHA (Occupational Safety & Health Administration), TSCA (Toxic Substances Control Act), Oil Pollution Act and Spill Prevention Control and Countermeasure Plans. Here is a breakdown of the air, water, and soil hazards posed by refineries:

• *Air pollution hazards:* Petroleum refineries are a major source of hazardous and toxic air pollutants such as BTEX compounds (benzene, toluene, ethylbenzene, and xylene). They are also a major source of criteria air pollutants: particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), hydrogen sulfide (H2S), and sulfur dioxide (SO2). Refineries also release less toxic hydrocarbons such as natural gas (methane) and other light volatile fuels and oils. Some of the chemicals released are known or suspected cancer-causing agents, responsible for developmental and reproductive problems. They may also aggravate certain respiratory conditions such as childhood asthma. Along with the possible health effects from exposure to these chemicals, these chemicals may cause worry and fear among residents of surrounding communities. Air emissions can come from a number of sources within a petroleum refinery including: equipment leaks (from valves or other devices); high-temperature combustion processes in the actual burning of fuels for electricity generation; the heating of steam and process fluids; and the transfer of products. Many thousands of pounds of these pollutants are typically emitted into the environment over the course of a year through normal emissions, fugitive releases, accidental releases, or plant upsets. The combination of volatile hydrocarbons and oxides of nitrogen also contribute to ozone formation, one of the most important air pollution problems in the United States**.**

• *Water pollution hazards***:** Refineries are also potential major contributors to ground water and surface water contamination. Some refineries use deep-injection wells to dispose of wastewater generated inside the plants, and some of these wastes end up in aquifers and groundwater. These wastes are then regulated under the Safe Drinking Water Act (SDWA). Wastewater in refineries may be highly contaminated given the number of sources it can come into contact with during the refinery process (such as equipment leaks and spills and the desalting of crude oil). This contaminated water may be process wastewaters from desalting, water from cooling towers, stormwater, distillation, or cracking. It may contain oil residuals

and many other hazardous wastes. This water is recycled through many stages during the refining process and goes through several treatment processes, including a wastewater treatment plant, before being released into surface waters. The wastes discharged into surface waters are subject to state discharge regulations and are regulated under the Clean Water Act (CWA). These discharge guidelines limit the amounts of sulfides, ammonia, suspended solids and other compounds that may be present in the wastewater. Although these guidelines are in place, sometimes significant contamination from past discharges may remain in surface water bodies.

• *Soil pollution hazards*: Contamination of soils from the refining processes is generally a less significant problem when compared to contamination of air and water. Past production practices may have led to spills on the refinery property that now need to be cleaned up. Natural bacteria that may use the petroleum products as food are often effective at cleaning up petroleum spills and leaks compared to many other pollutants. Many residuals are produced during the refining processes, and some of them are recycled through other stages in the process. Other residuals are collected and disposed of in landfills, or they may be recovered by other facilities. Soil contamination including some hazardous wastes, spent catalysts or coke dust, tank bottoms, and sludges from the treatment processes can occur from leaks as well as accidents or spills on or off site during the transport process.

Market and environmental forces changing the face of the petroleum industry

The U.S. petroleum refining industry has come under considerable strain because of several important factors and changes in the industry. Over the years, there has been an increased demand for petroleum products and a decrease in U.S. production; however, there has been no new major refinery construction in the United States in the last 25 years. This lack of infrastructure growth has caused a tremendous strain on the industry in meeting existing demand, and the U.S. has had to increase the amounts of imports to meet these needs.

The Clean Air Act and stringent state regulations have also caused the industry to incur extremely high costs for environmental compliance. These costs are accrued because refineries must produce reformulated, cleaner-burning gasoline, which require companies to replace or modify existing equipment with devices for controlling emissions. These costs of compliance are having a detrimental effect on refineries trying to expand and to keep pace with the country's increasing demand.

The cost of meeting environmental regulations has led many petroleum companies to join with the federal and state governments in reducing the amounts of hazardous air pollutants being released. Consent decrees between the petroleum industry and EPA have been made to reduce air emissions by refineries. One particular agreement was made between the state of Delaware, Louisiana and the Northwest Air Pollution Authority to reduce air emissions of nitrogen oxide and sulfur dioxide from nine refineries by more than 60,000 tons per year (EPA, 2001). The settlements are an effort to reduce the amounts of illegal releases of harmful air pollutants from these refineries by installing up-to-date pollution control devices and reducing emissions from leaking valves, flares and process units within the refinery. This type of collaboration between refineries and the state and federal governments provides a cooperative effort towards addressing environmental concerns within the industry.

Additional information on this topic may be obtained from the following resources:

• AP-42. Fifth Edition, Volume I *Chapter 5: Petroleum Industry*. U.S. Environmental Protection Agency, January, 1995. http://www.epa.gov/ttn/chief/ap42/ch05/.

• U.S. Department of Energy (DOE). *Energy and Environmental Profile of the U.S. Petroleum Refining Industry*. Office of Industrial Technologies, December, 1998. http://www.oit.doe.gov/petroleum/pdfs/profile.pdf.

• U.S. Environmental Protection Agency (EPA). Title 40 CHAPTER I PART 61 NESHAPS (National Emission Standards for Hazardous Air Pollutants). http://www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr61_00.html

• Department of Justice, U.S. Environmental Protection Agency (EPA). *Clean Air Agreements Reached with Petroleum Refiners*; *Settlements with Motiva, Equilon and Deer Park Refining Will Reduce Air Pollution in Several States.* Press Release. March 2001. http://www.epa.gov/compliance/resources/cases/civil/caa/motivapr.pdf

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