INDUSTRIAL PROCESS - PETROLEUM REFINING

A. Standard Industrial Classification (SIC)

S.I.C. Group No. 291 - Petroleum Refining

S.I.C. Industry No. 2911- Petroleum Refining

Establishments are primarily engaged in the production of petroleum products (gases, gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricating oils, asphalt, coke, pitch) from crude oil and fractionation products of crude oil, through processes including straight distillation of crude oil, redistillation of unfinished petroleum fractions, cracking and other processes. Establishments primarily engaged in producing gasoline from natural gas are classified with mining industries. Those manufacturing lubricating oils and greases by blending and compounding purchased materials are included in Industry 2992, along with establishments which primarily re-refine used lubricating oils(1).

B. Process Descriptions

The raw material of the petroleum refining industry is crude oil, a substance which is an extremely variable mixture of thousands of hydrocarbon compounds (alkanes, cycloalkanes, aromatics) containing from 1 to 40 or more carbon atoms, along with small quantities of sulfur compounds (including hydrogen sulfide), vanadium, arsenic, mercury, carbon dioxide, and nitrogen, which are collectively referred to as impurities. Mexico and Texas oilfields usually contain high-sulfur crude oils. The Pennsylvania crude oils are generally rich in long chain alkanes with excellent lubricating properties. Crude oil composition varies according to the geological strata of its origin(2). The storage of crude oil is one refinery operation.

Crude oils are processed into intermediates which are further refined, blended, purified, and packaged for sale to chemical plants, consumers of motor fuels and heating oils, and construction industries, among others. Refinery operations leading to the intermediates and final products include the following:

1. Fractionation. Fractionation is a distillation procedure whereby the crude oil is separated into "cuts" with defined boiling ranges. In order of increasing boiling range (also decreasing volatility and increasing molecular weight) these cuts are: methane and ethane gas, liquified petroleum gas (LPG), gasoline, white spirits and solvents (Stoddard Solvent), kerosene, jet fuels, heating fuels and diesel fuels, gas oil, residual (heavy) heating oils and diesel fuels, lubricating oils, waxes, and asphaltic bitumens and pitch. Each cut contains many aromatic, paraffinic and cycloparaffinic compounds within a given molecular weight range. Heating fuel fractions distill from approximately 200-350°C and may contain a mixture of aliphatic and aromatic hydrocarbons with 10-23 carbon atoms (e.g., hexadecane, heptadecane, naphthalenes, and polycyclic aromatic hydrocarbons including benzopyrenes. Vacuum distillation of residual oils produces lubricating oils and heavy fuel oil components for blending.

2. Cracking. Cracking includes catalytic, thermal and hydrocracking processes which increase the yield of isooctanes by the breakdown and reforming of heavier hydrocarbons in the heating fuel and residual oil cuts. The material used for cracking depends upon the demand for gasoline at the expense of other petroleum products. Gases liberated during cracking are also recycled into other petroleum products.

3. Molecular Rearrangement. Molecular rearrangement includes polymerization, alkylation, reforming and isomerization reactions. This is another methodology utilized in enriching gasoline and motor fuels for antiknock properties.

4. Extraction Procedures. Extraction procedures are employed for separating aromatic from paraffinic hydrocarbons in a cut. Solvent dewaxing removes long-chain alkanes from jet fuel and kerosene. Solvent refining is employed in removing benzopyrenes and other polycyclic aromatic hydrocarbons from lubricating oils to yield white mineral oils used industrially and pharmaceutically.

5. Product Finishing. Product finishing includes desulfurization, sweetening of gasolines, finishing lubricating oils, blending various intermediate stocks and packaging. The procedures are basically removal of objectionable impurities which might be malodorous or corrosive, blending of gasoline cuts with cracked and rearranged intermediates to meet fuel octane requirements, blending diesel fuel cuts with cracked stocks to improve hexadecane content (cetane number), blending of lubricating oils, and addition of various substances (additives) to impart color, decrease corrosiveness, or improve the function of the petroleum product.

In general, shut-down and start-up and maintenance procedures in a given refinery are designed to eliminate risks of explosion of vapors, fires and other hazards. Opening and closing of appropriate valves, checking for oxygen content and hazardous vapors when entering confined areas, utilizing hot environment procedures, and the wearing of protective clothing impervious to oils are standardized procedures among petroleum refinery workers(2).

C. Chemical and Physical Agents of Possible Concern

Chemical and physical agents of potential concern in the petroleum refining industry are discussed separately, although some overlap may occur. In most cases, not all employees would be exposed to all hazardous entities, and most substances would be likely to occur in complex mixtures.

1. Physical Agents. An exhaustive discussion of personnel and plant safety aspects of the petroleum industry was written by J. A. Herbert, in Section 9 of the Bland and Davidson (1967)(3).

The following is a list of some potentially dangerous circumstances:

a. *Hot environments*. Heat stress exhaustion is documented in petroleum refinery workers(2,3,4).

b. *Excess noise.* Impaired hearing and lowered work efficiency result(3).

c. *Electrical work.*

d. *Welding.* Exposure to ultraviolet rays occurs in electrical welding(3).

e. *Fires; explosions.*

f. *Confined areas.* Examination of tanks and vessels may expose worker to toxic vapors and fumes, or cause asphyxiation due to insufficient oxygen levels(2,3).

g. *Pneumatic hammers and chisels, scaffolds, cables, and chains; moving vehicles, hand tools.* These, among others, can be involved in accidents to employees who are or are not properly protected(3).

h. *Work on pipelines.* Cutting and welding procedures are utilized(3). Asbestos (a pipeline insulator) is toxic and carcinogenic.

i. *Work on vessels, exchangers, drums, and tanks.* In addition to hazards of confined areas, steaming, welding, and ventilating with various displacement media (carbon dioxide, steam, inert gas) are potentially dangerous activities(3).

2. Chemical Agents. This category encompasses a profusion of substances to which any number of employees may be exposed acutely, chronically or never. In processing, handling and distribution, the operations are designed in a manner such that the product is contained and not released to the atmosphere (except by controlled release). An accident, rupture or breakdown of a containing device or failure of a control system can occur. Significant sources of leaks are vents, drainage or collection points and pump glands, while solid or welded pipelines and pressure vessels do not usually contribute to leakage of process materials(5).

Potentially hazardous chemicals include the hydrocarbon components of crude oil and all of its distillates, residues, and reformates, the impurities of crude oils, catalysts used in various processes, and additives used to improve the final petroleum products.

a. *Normal alkanes.* The range to be considered includes gases (methane, ethane, propane, butane), volatile liquids (C_5–C_{10}), more viscous liquids (C_{11}–C_{17}), and solid waxes (C_{18}– $>C_{34}$). Lubricating oils may be rich in viscous alkanes. Alkanes are also one component of crude oils, fuels, heating oils, kerosene, gasoline, greases, and waxes.

b. *Cyclic alkanes.* Also called naphthenes or cycloparaffins, they occur in various percentages in crudes and mostly all petroleum products that contain normal alkanes. Compounds with one to four rings have been isolated and identified in crude oil, and include cyclopentane, cyclohexanes and substituted 5- and 6-membered ring systems.

c. *Aromatic hydrocarbons*. Benzene, alkyl-substituted benzenes, naphthalene, indanes, tetralins, alkyl-substituted naphthalenes, acenaphthenes, fluorenes, tricyclic compounds such as phenanthracenes and anthracenes, and polycyclic aromatic hydrocarbons including benzopyrenes are among the isolated and identified compounds of this class which occur in crude petroleum, and in most petroleum products from gasoline to asphalt and pitch.

d. *Olefins*. Unsaturated alkanes are present in low concentrations in crude oil, but cracking and reforming form most of them, and they occur in most petroleum products (e.g., ethylene gas, fuel oils, and lubricating oils).

The percentage of alkanes, cycloalkanes and aromatic hydrocarbons in crude oils, and petroleum products, vary considerably, depending upon both the source of the crude oil and the refinery processes and blendings which go into forming the final petroleum products.

e. *Impurities*. Vanadium, sulfur, arsenic compounds, mercury, carbon dioxide, and nitrogen may be found in crude oils and some petroleum products in trace amounts. Hydrogen sulfide gas fumes are one source of poisoning(3).

f. *Catalysts*. Exposure to catalysts employed in cracking and other refinery procedures is another potential hazard. The petroleum industry reveals some catalysts, while the chemical composition of others remains a guarded secret. One listing of compounds includes: alumina; aluminum chloride; antimony trichloride; bauxite; bentonite clay; clay; cobalt-molybdena; cobalt molybdate; cobalt oxides; copper; copper pyrophosphate: hydrochloric acid; hydrofluoric acid; iron oxide; kaolin clay; magnesia; molybdena; molybdenum; nickel sulfide; phosphoric acid; platinum; potassium; silica-alumina; sulfuric acid; and tungsten nickel sulfide(3).

Inert gases containing carbon monoxide, in combination with nickel or cobalt, form extremely toxic carbonyl compounds (e.g., nickel carbonyl)(2).

3. Additives. A multitude of additives is blended with petroleum products. Each additive usually serves one function in one particular product (e.g., viscosity index improvers in lubricants; antistall agents in motor fuels). Anticorrosives, odorants, detergents, oilyness improvers, colorants, dispersants and gum inhibitors are other examples. The additive industry and petroleum industry tightly guard the chemical composition of some additives. Among the additives which are not secret are the following(3):

a. *Tetraethyl lead*. It is used to improve motor fuels.

b. *Gasoline antioxidants*. Aromatic amines and alkyl-substituted phenols are included.

c. *Oil soluble dyes*. Used mainly in aviation fuels, these include: 1,4-bis(alkylamino)anthraquinones (blue); methyl derivatives of 4-(phenylazo)-2-naphthols (reds); (phenylazo)-2-naphthols (orange); and N,N-dimethyl-4-(phenylazo)benzenamine (yellow).

d. *Gum inhibitors in aviation fuels.* Examples are: N^1,N^4-bis (1-methylpropyl)-1,4-benzenediamine; 2,4-dimethyl-6-(1,1-dimethylethyl)phenol; 2,6-bis(1,1-dimethylethyl)-4-methylphenol.

e. *Diesel fuel ignition improvers.* Amyl nitrate and hexyl nitrate mixtures are utilized.

f. *Corrosion inhibitors in diesel fuels.* Fatty acid amines and amides, alkyl sulfoxides and aliphatic- or aromatic-substituted dimercapto-thiazoles are included.

g. *Antioxidants in diesel fuels.* These include bis(1,1-dimethyl-ethyl)phenols and substituted benzenediamines.

h. *Magnesium-bearing additives.* These are used in residual fuel oils as anticorrosives and antifouling agents.

i. *Lubricating grease thickening agents.* These include soaps of aluminum, barium, calcium, lithium, sodium and strontium; clays and silicas; arylureas and phthalocyanin pigments.

j. *Lubricating grease fillers.* Some examples are asbestos, graphite, metal oxides, metal flakes or powders and metal sulfides.

D. Number of Workers Exposed or Employed

The maximum number of workers in the entire petroleum refining industry (SIC #291) in 1976 was reported as 157,000 of which 97,800 were classed as "production" workers(6). These figures are difficult to compare to the total of 100,179 reported elsewhere for 1973(7). This latter figure represents 633 "units" of which 190 employed 100 or more persons. Of this 190, 53 employed 500 or more workers.

Union sources were in agreement with each other, but not in agreement with the "government" figures. Both the Oil, Chemical and Atomic Workers International Union (OCAW) and the International Brotherhood of Teamsters placed the industry total at 135,000, of which 75,000 were felt to be production workers. Both disputed the government practice of lumping all non-supervisory workers at petroleum refinery sites together. Such individuals as computer operators and clerical personnel should not be included with refinery production workers from an occupational hazard standpoint, according to the union representatives(8,9).

A representative of a much smaller union, the International Union of Petroleum Workers(10), which counts about 3,000 maintenance workers at both refineries and oil fields as its membership, felt that there were closer to 90,000 refinery personnel. As his membership is not taken from actual production workers, however, his perception is legitimately altered.

It should be noted that some workers are exposed to the conditions within a refinery without being in any group alluded to above. An example is the 600-member Petroleum Workers Union, in San Francisco, which handles gas and oil deliveries in the San Francisco area. These employees work directly in refinery complexes.

An additional discrepancy uncovered is related to the count of refinery units. OCAW places the figure at 285-300(8), the Bureau of the Census reports 633(7).

E. Trends of Process Use

Trends of interest would affect either the number of employees or their exposure to possibly toxic substances. The number of employees in the petroleum refining industry changes little provided that new refineries are not built. In other words, few additional workers are required to increase a refinery from 75% of capacity to 90% of capacity(8,9).

The mix of materials to which the worker is exposed may well change in both the near term and long term, however. Decreased use of tetraalkyllead compounds in automotive gasoline lessens worker exposure to those substances, but means the gasoline contains more aromatics. These aromatics are then unavailable for other use, as United States' reformers are already operating at capacity(11). While several new billion-pound-per-year ethylene units have been announced by the petrochemical industry, the feedstocks for them will be from existing refinery capacity; the new units will simply employ naphtha and gas oil instead of the ethane previously used in ethylene production. Such heavy oils must be imported, however(11).

The picture presented is that existing refineries will continue in operation, and will continue to produce essentially the same substances utilizing essentially the same personnel. The only change will be in the proportionate quantities of these substances produced; this change is dependent on changing demands, international economics and politics, and even the weather.

F. Incidence of Mortality, Injury, and Morbidity

The incidence of mortality, injury and morbidity among petroleum workers has not been sufficiently documented, in most cases, to make an accurate assessment of the situation(12).

Dr. N. K. Weaver, medical director of the American Petroleum Institute, said that existing data indicates that the health of refinery workers is good in relation to the general population and morbidity and mortality rates in other industries(13).

The "existing data", however, is far from clear-cut. An epidemiologic study, started in April 1977, will compare deaths among OCAW petroleum workers during the past 30 years, relating cause of death to type of occupational exposure(14).

Most studies so far have attempted to examine the risks of developing excessive cutaneous and pulmonary cancers, noting that the carcinogen benzo[a]pyrene is present in crude petroleum, residues, soots and air pollution around refineries. One study(15) explored skin and lung cancer mortality over a 29-year period, ending in 1963, in employees of a Texas oil refinery. There were 377 cancer deaths reported among 15,437 employees. The mortality rates were compared with those of the general adult male population of the same geographic area, and were no higher than expected. There was no greater incidence of lung cancer deaths in refinery employees than among employees in production, transportation, sales or exploration for the same company.

It was concluded that the air pollutants in refinery operations were not a lung cancer hazard to employees, based on cancer mortality records.

A more recent study(11) disagreed. A national survey compared cancer mortality rates of approximately 50,000 white males comprising the population of 39 U.S. counties in which the petroleum industry is heavily concentrated, with a demographically matched control population of white males not heavily exposed to oil refinery pollution, over the years 1950-1969. For a total of 23 cancer sites, mortality was significantly higher ($p<0.01$) among petroleum refinery workers and nearby residents than among controls. The highest mortality rates were for cancers of the nasal cavity, nasal sinuses and lung. Also significant were mortality rates for malignant melanoma, other skin cancers, and cancers of the testes, stomach, and rectum ($p<0.05$), while bladder and liver cancers were not excessive. The cause of the excessive cancer mortality was not determined, but polycyclic aromatic hydrocarbons involved in the manufacture of petroleum, and present in the air around refineries, were implicated.

A review of the literature concerning occupational diseases related to exposure to fuel oils and lubricants in various industries (e.g., mule spinners' cancer, diesel fuel dermatitis) was completed in 1978(16).

G. Biologic Effects

It would be beyond the scope of this information profile to discuss every possible hydrocar bon, impurity, additive, catalyst, and other agent present in the environment of a petroleum refinery which could adversely affect the health of its employees. Instead, some of the toxic substances which have been delineated in Section C. will be surveyed, in order to provide material by which to assess overall hazards and recommend further research.

1. Inorganic Substances.

a. *Aluminum oxide.* This may cause nodular silicosis in lungs of humans, but there is no evidence of pneumoconiosis. It is considered an "inert" dust(17).

b. *Antimony.* Chronic poisoning by inhalation of antimony compounds leads to myocardial degeneration and dysfunction. Respiratory tract, lung and gastrointestinal disorders have also been reported. It accumulates in the body due to its slow excretion rate(17).

c. *Arsenic.* Its metallic compounds, when inhaled as dust, cause skin irritation and mucous membrane injury, ulcers and perforation of the nasal septum, but no excess cancer mortality. Dermatitis is reported(17).

d. *Asbestos*. This broad term embraces a number of fibrous mineral silicates. Carcinogenicity to lungs, asbestosis, and asbestos warts are well documented. A NIOSH Revised Recommended Asbestos Standard is available (17,18,19,20).

e. *Cobalt*. Metal dust and fumes may cause chronic interstitial pneumonitis and dermatitis after occupational exposure(17).

f. *Copper*. Copper fumes irritate the upper respiratory tract, cause metal fume fever and may discolor skin and hair. Dusts and mists of copper salts are nasal mucous membrane irritants; gastrointestinal tract disorders, anemia, dermatitis, corneal opacity and conjunctivitis are documented after chronic exposure(17).

g. *Hydrogen sulfide*. Hydrogen sulfide causes respiratory paralysis and death. At lower concentrations, pneumonia, keratitis, conjunctivitis, nausea and headache occur(17,19).

h. *Nickel*. Metallic nickel is carcinogenic. Nickel carbonyl gas inhalation produced squamous cell carcinoma in lungs of rats. Simple dermatitis and neurodermatitis occur in nickel platers(17).

i. *Nickel carbonyl*. Nickel carbonyl gas causes acute pneumonitis, liver toxicity, lung cancer and cancer of nasal sinuses in exposed workers(17).

j. *Platinum*. Soluble salts may cause rhinitis, allergic asthma, and "platinosis" (not described) after inhalation(17).

k. *Vanadium*. Vanadium is very poisonous. Nonlethal doses produce acute respiratory system inflammation, conjunctivitis and dermatitis. Chronic effects are unknown(17).

2. Organic Substances.

a. *Asphalt fumes*. Petroleum asphalt fumes contain polycyclic aromatic hydrocarbons, such as benzo[a]pyrene, which are carcinogenic and mutagenic. Phenanthrene is also present, and may cause photosensitization reactions of redness, peeling, and skin discomfort following exposure to sunlight(17,21).

b. *Benzene*. As an acute poison, it produces narcosis. Chronic exposure leads to bone marrow toxicity and aplastic anemia which is frequently fatal. Leukemia is also reported(17). A NIOSH criteria document is available(22). OSHA is preparing a benzene standard document(23).

c. *Cyclohexane*. Vapors may irritate eyes and mucous membranes. Some liver and kidney changes in rabbits were observed after chronic vapor exposure(17).

d. *Gasoline*. It is an acute irritant to the conjunctiva of the eye, and can cause asphyxiation in high vapor concentrations. It is a recognized carcinogen, possibly due to its benzene content. Chronic systemic toxicity is unknown(24).

e. *Kerosene.* Skin contact with kerosene may cause dermatitis. Deaths are reported among children after drinking it. Pneumonia also occurs after oral administration(15).

f. *Lubricating oils.* Those containing polycyclic aromatic hydrocarbons are carcinogenic to human skin. Oil acne is also reported. Purified lubricating oil is medicinal mineral oil, a laxative. Chronic oral dosing causes oil pneumonia and gastrointestinal duct disturbances(16).

g. *Naphtha.* Petroleum naphthas are solvents containing xylenes, ethylbenzenes, octanes, nonane and cyclohexanes. Vapor inhalation can cause narcosis and irritation of eyes and respiratory passages. Some naphthas contain sufficient benzene to warrant concern for carcinogenicity(17).

h. *Naphthalene.* Exposure to vapors causes headache, nausea, corneal injury, and kidney damage. Ingestion may lead to severe hemolytic anemai(17).

i. *Octane.* Vapors cause narcosis and acute mucous membrane irritation(17). A NIOSH criteria document discusses octane, heptane, hexane and pentane(25).

j. *Paraffin wax.* Fumes may cause respiratory tract irritation or nausea, although paraffin is considered nontoxic(17).

k. *Stoddard solvent.* This flammable petroleum product contains about 15-20% trimethylbenzenes and 80-85% of the n-alkanes, nonane and decane. Vapors cause eye irritation, conjunctival injection and narcosis. Chronic effects are unknown(17).

l. *Tetraethyl lead.* It is absorbed through the skin and causes high urinary lead levels. Liver, pancreas, kidney, endocrine gland and nervous system effects have been observed in animals after oral, inhalation or cutaneous applications(17).

In concluding this section on biological effects, it has been observed that the petroleum industry has no baseline data on the toxicology of gasoline, fuel oil or other petroleum products. The American Petroleum Institute is reportedly spending over one million dollars a year on research in this area(13).

H. Review of Health Hazard Evaluations

Two NIOSH Health Hazard Evaluations have been made available, concerning two problem areas in the petroleum industry. One(4) concerns asbestos exposure among 4 employees working with pipe insulation, and it also discusses hot environments. The other evaluation is for 9 asphalt workers exposed to petroleum pitch in an oil refinery(21).

Interviews with the 4 workers exposed to asbestos did not reveal asbestosis symptoms, and medical records were negative. The workers had worn respirators and disposable paper overalls for protection. Thirty working locations were sampled for airborne asbestos, and levels varied from 0.1-0.9 fibers/cc air (less than 5μ in length). Personal samplers revealed asbestos levels from 0.6 to 3.3 fibers/cc, and an 8-hr TWA was estimated at 0.3-0.6 fibers/cc, based on the fact that asbestos exposures were intermittent.

Two cases of overexposure to heat (heat exhaustion) were attributed to wearing the paper coveralls.

Seven of 9 interviewed petroleum pitch workers experienced recurrent skin redness, peeling and burning, similar to sunburn, during the summer, and 6 reported eye and throat irritation. They had worked for 3-4 years in asphalt. A NIOSH survey team of 4 which was exposed to petroleum pitch for 1 day reported experiencing skin burning, smarting and stinging which cleared up in 24 hours. Environmental sampling on a day with light road traffic, little or no wind and a wetted truck roadway revealed air levels of pitch below 0.2 mg/m^3 (vapors and particulates). The polycyclic aromatic compounds in pitch were believed responsible for the increased sensitivity of the skin of the pitch workers to sunlight. Phenanthrene is a known photosensitizer(21).

J. Review of Standards

A review of recommendations and standards set up for various substances which may be sampled in the environment of a petroleum refinery might include every individual hydrocarbon compound which occurs in crude and refined petroleum (alkanes from methane to tetratriacontane, C_{34}) cycloalkanes, and aromatics from benzene and substituted benzenes, through naphthalenes, anthracenes, and phenanthrenes to benzopyrenes and other polycyclic aromatic hydrocarbons. In addition, the standards for catalysts, impurities and other substances in workroom air (e.g., asbestos insulation) might be considered. Such an in-depth treatment is beyond the scope of the present information profile. The following table lists TLV's and other standards for some substances representative of larger groups of petroleum hydrocarbons, and other compounds discussed previously in the report. These values might be meaningless, due to the possibility of potentiation, synergism, antagonism and other effects of combining two or more substances in the refinery environment.

Table J-1. Review of Standards

Substance	Standard	Agency*	Reference
Aluminum oxide	15 mg/m^3; 8-hr TWA	OSHA	26
	10 mg/m^3; TLV	ACGIH	27
Antimony	0.5 mg/m^3; 8-hr TWA	OSHA	26
Arsenic	0.5 mg/m^3; 8-hr TWA	OSHA	26
Asbestos	10^5 fibers/m^3; 10-hr TWA	NIOSH	18
	2 x 10 fibers/m^3; 8-hr TWA	OSHA	26
Asphalt-fumes	5 mg/m^3; ceiling, 15-min	NIOSH	28
	2.5 mg/m^3; 8-hr TWA	OSHA	26
Benzene	1 ppm; 8-hr TWA	OSHA	29
	5 ppm; ceiling	OSHA	29
	1 ppm; ceiling, 60-min	NIOSH	28
Cobalt	100 μg/m^3; 8-hr TWA	OSHA	26
	0.5 mg/m^3 TLV	ACGIH	27
Copper-dust, mist	1.0 mg/m^3; 8-hr TWA	OSHA	26
-fume	100 μg/m^3; 8-hr TWA	OSHA	26
Cyclohexane	300 ppm; 8-hr TWA	OSHA	26
Hydrogen sulfide	10 ppm; ceiling, 10-min	NIOSH	28
	20 ppm; ceiling	OSHA	26
Naphtha	100 ppm; 8-hr TWA	OSHA	26
Naphthalene	10 ppm; 8-hr TWA	OSHA	26
Nickel	1 mg/m^3; 8-hr TWA	OSHA	26
	15 μg/m^3; 10-hr TWA	NIOSH	28
Nickel carbonyl	1 ppb; 8-hr TWA	OSHA	26
	50 ppb; TWA	ACGIH	27

Table J-1. Review of Standards (Cont.)

Substance	Standard	Agency*	Reference
Octane	500 ppm; 8-hr TWA	OSHA	26
	300 ppm; TWA	ACGIH	27
	385 ppm; 10-hr TWA	NIOSH	25
Paraffin wax-fumes	2 mg/m^3; TWA	ACGIH	27
Platinum-soluble	2 $\mu g/m^3$	OSHA	26
Stoddard solvent	100 ppm; TWA	ACGIH	27
	500 ppm; 8-hr TWA	OSHA	26
Tetraethyl lead (as Pb)-skin	0.1 mg/m^3;TWA	ACGIH	27
	75 $\mu g/m^3$; 8-hr TWA	OSHA	26
Vanadium pentoxide dust	500 $\mu g/m^3$; ceiling	OSHA	26
Vanadium pentoxide fumes	100 $\mu g/m^3$; ceiling	OSHA	26
	0.05 mg/m^3; TWA	ACGIH	27

*-OSHA values are federal regulations, all other values are merely recommendations.

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INFORMATION PROFILES ON POTENTIAL OCCUPATIONAL HAZARDS

Final Report - April, 1978

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