

SRC TR 80-610

PB81147522



INFORMATION PROFILES ON
POTENTIAL OCCUPATIONAL HAZARDS

VOLUME III. INDUSTRIAL PROCESSES

Center for Chemical Hazard Assessment
Syracuse Research Corporation
Merrill Lane
Syracuse, New York 13210

Final Report
Contract No. 210-78-0019 (32)

July 1980

Prepared for:
National Institute for Occupational Safety and Health
5600 Fishers Lane
Rockville, Maryland 20857

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

[Faint, illegible text]

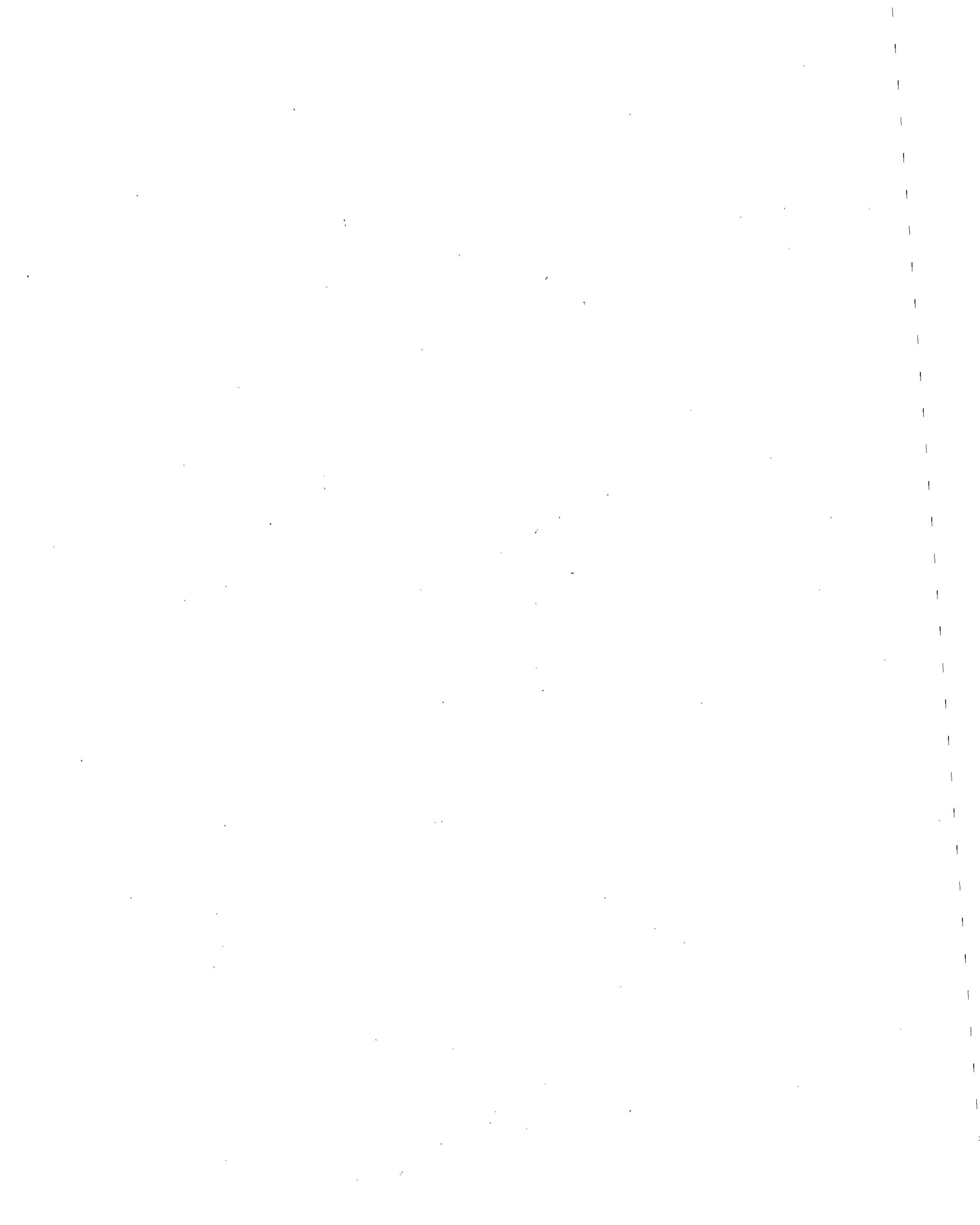
[Faint, illegible text]



GENERAL DISCLAIMER

This document may be affected by one or more of the following statements

- **This document has been reproduced from the best copy furnished by the sponsoring agency. It is being released in the interest of making available as much information as possible.**
- **This document may contain data which exceeds the sheet parameters. It was furnished in this condition by the sponsoring agency and is the best copy available.**
- **This document may contain tone-on-tone or color graphs, charts and/or pictures which have been reproduced in black and white.**
- **This document is paginated as submitted by the original source.**
- **Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.**



1. REPORT DOCUMENTATION PAGE		2. REPORT NO. NA	3. REPORT'S ACCESSION No. PDB1 147522
4. Title and Subtitle Potential Occupational Hazards, Volume III, Industrial Processes, Electric Power Generation Utilities		5. Report Date July 1980	
7. Author(s) Anonymous		6. NA	
9. Performing Organization Name and Address Center for Chemical Hazard Assessment Syracuse Research Corporation Syracuse, New York		8. Performing Organization Rep. No. NA	
		10. Project/Task/Work Unit No. NA	
		11. Contract(C) or Grant(G) No. (C) 210-78-0019 (G)	
12. Sponsoring Organization Name and Address National Institute for Occupational Safety and Health Rockville, Maryland		13. Type of Report & Period Covered Contract Final Report	
		14. NA	
15. Supplementary Notes NA			
16. Abstract (Limit: 200 words) <p>ABSTRACT: This information profile on electric power generation utilities (SIC-4911) is part of a group of 46 such profiles that provide information about chemicals or industrial processes considered to be potential occupational hazards. Each profile contains summary data on known and suspected health effects, the extent of worker exposure and the industrial importance of either a single chemical, class of chemicals, or a particular industrial process. The report was developed for use by occupational safety and health professionals in industry, and labor and other areas, to provide them with a synopsis of information in their workplaces.</p>			
17. Document Analysis a. Descriptors <p>Toxicology Physiological-effects Chemical-properties Physical-properties Occupations Industrial-processes Work-environment Safety-research</p>			
b. Identifiers/Open-Ended Terms			
c. COSATI Field/Group			
18. Availability Statement Available to the public		19. Security Class (This Report) NA	21. No. of Pages 22
		20. Security Class (This Page) 1<	22. Price

1931

1

1

1

GENERAL DISCLAIMER

This document may be affected by one or more of the following statements

- **This document has been reproduced from the best copy furnished by the sponsoring agency. It is being released in the interest of making available as much information as possible.**
- **This document may contain data which exceeds the sheet parameters. It was furnished in this condition by the sponsoring agency and is the best copy available.**
- **This document may contain tone-on-tone or color graphs, charts and/or pictures which have been reproduced in black and white.**
- **This document is paginated as submitted by the original source.**
- **Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.**

Disclaimer

The contents of this report are reproduced as received from the contractor, and have not been edited nor evaluated by the National Institute for Occupational Safety and Health (NIOSH). The opinions, findings, and conclusions expressed are not necessarily those of NIOSH, nor does mention of company names or products constitute endorsement by NIOSH.



INTRODUCTION

An information profile is a working paper used by the National Institute for Occupational Safety and Health (NIOSH) to assist in establishing Institute priorities. It is an initial step in determining the need to develop comprehensive documents or to initiate research. Each profile summarizes data on known and suspected health effects, the extent of worker exposure, physical and chemical properties, and the industrial importance of individual chemicals and classes of chemicals. The profile may also be used by industry, labor, and the occupational health community as a synopsis of information on each subject and to identify possible health hazards associated with their workplaces.

Although detailed literature searches are conducted using computerized and manual searching techniques to identify pertinent and recent information, not all the literature obtained is incorporated in the report due to the summary nature of the profiles. Further, literature published after 1978 may not be included in these profiles because it was generally unavailable at the time the search was completed.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

TABLE OF CONTENTS

	<u>Page</u>
DENTISTRY	1
ELECTRIC POWER GENERATION UTILITIES	34
ELECTRONICS MANUFACTURE	57
FERROUS SMELTING AND STEEL MANUFACTURE	88
THE FERTILIZER INDUSTRY	134
THE FOOD PROCESSING INDUSTRY	172
GLASS AND CERAMICS MANUFACTURE	223
HAIRDRESSING AND BARBERING	265
INFRASONICS	324
JEWELRY MANUFACTURING	335
NONFERROUS SMELTING	364
OIL WELL DRILLING AND SERVICES	412
THE PETROCHEMICAL INDUSTRY	435
PLASTICS AND RESINS MANUFACTURE	520
THE WOOD-BASED PANEL PRODUCTS INDUSTRY	583
THE WRECKING AND DEMOLITION INDUSTRY	613



ELECTRIC POWER GENERATION UTILITIES

I. SCOPE OF PROFILE

Electric power generating and transmitting systems have been reviewed for the purpose of identifying the potential occupational health hazards associated with the utilities industry.

The industry, Standard Industrial Classification (SIC) 4911 (Appendix A), is engaged in the generation, transmission, and distribution of electric power for sale from coal, oil, gas, hydroelectric, and nuclear fuels.

The generated power is distributed throughout the nation by extensive high tension transmission and distribution systems. Additional power is also generated and distributed for captive use throughout industry.

II. SUMMARY

High pressure steam and high voltage are the foremost potential hazards associated with electric power generation operations. These are well controlled, however, and are not always fully recognized as potential hazards by the industry. Coal-fueled plants are judged to present greater potential hazards than plants fueled by other sources, due to exposures associated with feed pulverizing and fly ash disposal operations. Nuclear power plants are not discussed in this report.

There is debate over the possibility of adverse health effects due to occupational exposure to high voltage transmission lines. Certain studies have suggested the potential of a health risk from electromagnetic radiations that originate from high tension systems and generating installations, but other ongoing studies have thus far indicated no adverse health effects.

III. STATISTICAL INFORMATION

In 1977, 262,000 production workers were employed in 3622 electric power plants (Anon., 1978a). This information is detailed as follows:

Number of Plants (1977)

Conventional Steam	951	(76%)*
Hydro	1,145	(10%)
Other	<u>1,526</u>	(14%)
Total	3,622	

* Fraction of total production

Employment (1977)

Total	320,000
Production workers	262,000

Production workers per plant

Distribution by number of employed

Under 10	28%
Under 20	44%
Under 50	70%
Under 100	85%
Over 100	15%

Incidence rates for injuries and illnesses for electric services (SIC 491), compared with rates for all transportation and public utilities (SIC 49) and all U.S. manufacturing, are presented in Table 1.

Table 1. Incidence Rates for Injuries and Illnesses for 1976
(Anon., 1979a)

	<u>SIC 491</u>	<u>SIC 49</u>	<u>All Manufacturing</u>
Total Reported Cases for Injuries and Illness (Based on 100 full-time workers)	9.6	9.8	13.2
Injury cases	9.3	9.6	12.6
Illness cases	0.3	0.2	0.6
Lost workday cases	3.5	4.7	4.8
Lost workdays	62.8	94.0	79.5

IV. PRODUCTION AND TRENDS

The total power generation by the industry was 2124×10^9 kWh in 1977 (Anon., 1978a). Of this total, 1684×10^9 kWh were generated in privately owned plants (at a total revenue of \$46.3 billion), and 440×10^9 kWh in publicly owned facilities.

The annual rate of growth of total power generation was 4% between 1970 and 1977, and projected sales for 1980 are 2950×10^9 kWh (Anon., 1978a). Eighty-three percent of the new plants have production capacities over 500 MW.

The length of high voltage transmission lines (+200 kV) projected for the U.S. in 1980 is 110,000 miles (Anon., 1979b).

V. CHARACTERIZATION OF OPERATIONS

Electric power is generated primarily via the production of high pressure steam in fuel-fired boilers. The steam is used to drive multistage turbines, the prime movers of the electricity-generating machines. The major source of fuels used in electric power generation are fossil-fuels, as detailed in the following breakdown of consumption in the U.S. in 1977 (Anon., 1978a):

Coal	45.5%
Oil	14.7%
Gas	14.5%
Hydroelectric	11.8%
Nuclear	10.9%

Nuclear-fueled electric power generating plants do not, in general, differ in operation from other types of plants after the boiler stage. A discussion of pre-boiler operations in nuclear-fueled electric power generating plants is, however, beyond the scope of this report.

Electric power generation operations are detailed as follows:

Fuel Supply

The principal fuel, bituminous coal, is received by rail, truck, ship, and pipe line, and requires unloading, storing, drying, pulverizing, and blowing into the boiler furnaces. The combustion gases, which contain fly ash (largely iron, aluminum, and silicon oxides), are treated by electrostatic precipitators and, in some cases, by scrubbing to remove volatile sulfur compounds, mainly sulfur dioxide. In both operations, the waste materials, fly ash, and scrubber effluents are collected for disposal.

In a modern 500 MW station, approximately 200 tons of coal are used per hour, requiring disposal of 25-50 tons/hour of fly ash and approximately the same quantity of calcium sulfate waste mud, as estimated from engineering handbooks (Marks' Standard Handbook for Mechanical Engineers, 1978; Standard Handbook for Electrical Engineers, 1968). These steps are not required with oil or gas fuels.

Boiler Operation

The steam is produced by all fuels in steel tube boilers of highly developed design for safety, automatic control, and maximum reliability. Steam pressures usually exceed 200 psi and temperatures approach 1000°F. Zeolites and deoxidizers are used to purify feed water, a practice which is critical for the control of scale and corrosion in the boiler tubes (Schwartz, 1979). A boiler produces approximately 3-4 million pounds of steam per hour for a 500 MW station, and receives approximately 6000 gallons per minute of return condensate as boiler feed, as estimated from engineering handbooks (Marks' Standard Handbook for Mechanical Engineers, 1978; Standard Handbook for Electrical Engineers, 1968).

Power Generation

The electric power is generated by large, alternating current machines that produce three-phase power at a specific voltage, usually about 13.8 kV (Schwartz, 1979). The generator, usually hydrogen cooled, is driven by a multi-stage turbine over a pressure range, usually near 2 psia, that is fixed by condensing conditions. Cooling ponds or towers may be used as condenser coolants if other sources of cool water are not available. The condensate from the surface condenser shell is collected as boiler feed water, and the system may include tubular preheaters and economizers for heat economy purposes.

The generated power is delivered by cables to the bus bars of control panels, which are located in code designed control rooms. These panels are equipped with voltage regulators, automatic controls, and switches that are required for the delivery of the power to the step-up transformers of the power transmission system. The controls regulate generator-set output to meet load demands (Compiled from Schwartz, 1979; Marks' Standard Handbook for Mechanical Engineers, 1978; Standard Handbook for Electrical Engineers, 1968).

Power Transmission

High tension systems ranging from about 100 to 765 kV consist of one or sometimes two, three, or four wire systems mounted on wooden poles or steel towers in accordance with national electrical safety codes (Anon., 1977a), Electric Power Research Institute recommended designs (Anon., 1979b), and Public Service Commission regulations (Anon., 1978b). The systems are specially designed to control not only flashover between conductors but also electromagnetic radiation effects.

Descriptions of a number of transmission systems are tabulated in Anon., 1979b.

Distribution

The distribution systems consist of step-down substations that deliver serviceable voltage current to the consumers.

VI. ENGINEERING CONTROLS

In addition to the well established controls for the main power generation operations, considerable attention is required for the effective control of auxillary operations. In particular, the safe distribution and control of electric power is critically dependent on the selection of reliable, sensitive, and wear-resistant valves, meters, gauges, and switches, as well as on the use of automated and computerized equipment for control rooms and stations.

VII. POTENTIAL HEALTH HAZARDS

A computer printout that tabulates the results of a National Occupational Health Survey of eight SIC 4911 facilities, obtained from NIOSH, Cincinnati, indicates that workers in these facilities are exposed to a myriad of chemical substances. Many of the listings are nonspecific or innocuous (e.g., detergent, furniture polish, gum arabic, sodium chloride), but nearly 1000 chemicals were listed as present in the work areas of 2216 employees. Some of the chemicals and substances that appear to be more frequently encountered are listed in Appendix B. It should be noted that this printout quantifies exposure potential only by listing the number of total exposures for each chemical, and that no information is provided on the degree, duration, or source of exposure.

Some of the potentially hazardous materials and conditions that are commonly encountered in electric power generation and transmission operations are listed as follows:

Boiler and Generators

High pressure, high temperature steam from and in the boiler house.
Airborne coal and fly ash from pulverizers and from blowing precipitators.
Overheated working environments.
Noise, vibration, fuel oil, and gas leaks or spills.
Optical strains from high temperature combustion gases.
Boiler and boiler accessory repairs and maintenance.
Milk of lime scrubber liquors.
High voltage cables, bus bars, switches, etc.
Ultra high voltage fields.
High pressure steam leaks or blows.
Chlorinated biphenyl transformer fluids.
Faulty grounding and insulation.
Asbestos insulation, armature backing, and gaskets.
Mercury in switches and in instruments.
Lead sheathing.
Ozone and slip ring emissions.
Hydrogen generator coolants.

Transmission and Distribution

Possible electrical emission from high tension transmission lines and substation accessories.
Faulty substation grounding, insulators, etc.
Faulty switch controls.
High line repairs.
Damages from wind, storms, tornados, wrecks, etc.

Highly developed safety codes are so well established that the salient potential hazards from high pressure, high temperature steam and from ultra high voltage are hardly recognized by experienced members of the industry as genuine potential hazards. Furthermore, even the less significant potential hazards such as hot furnace gases and high speed machinery are well controlled and are not usually recognized as potential hazards. Coal-fueled plants are judged to present greater potential hazards than plants fueled by other sources, due to exposures to materials associated with coal pulverizing operations, and the disposal of fly ash and other impurities removed from the flue gases.

The possibility of deleterious effects from electromagnetic radiations originating from ultra high voltage transmission installations is unresolved. European experience and certain studies by American research groups have suggested the potential of a health risk from high tension systems and possibly under generator room and substation conditions, but ongoing studies by the Department of Energy and the Electric Power Research Institute have thus far indicated no adverse health effects (Anon., 1977b; Anon., 1978c; Zaffanella and Deno, 1978).

SRI International (Witwer et al., 1978) has recently completed a study for NIOSH on the potential health hazards and effects associated with the installation, maintenance, and operation of high-voltage transmission lines. Primary consideration was given to ozone, audible noise, electric shock, and high-intensity electromagnetic fields. Five thousand workers are estimated to be exposed at present, and an increase of 1000 workers per year is projected. The results of the SRI study (Witwer et al., 1978) are summarized as follows:

Ozone

Workers are potentially exposed to ozone if their work requires them to be near energized, high-voltage transmission lines. Although virtually all measurements show negligible ozone concentrations, the determinations have been indirect and have not corresponded to typical occupational exposures. Air dispersion models under worst-case conditions suggest that, in extreme situations, workers may be exposed to substantial ozone concentrations.

Ozone has severe potential human health effects, including loss of respiratory function, pulmonary edema, increased susceptibility to pulmonary infection, and carcinogenic/mutagenic and teratogenic effects, although

virtually all of the scientific evidence of these effects is based on animal rather than human data.

Audible Noise

Audible noise from high-voltage, alternating-current (ac) transmission lines occurs primarily in wet weather conditions. Conductor wetness affects audible noise generation; in particular, however, any matter such as water droplets or dust on transmission line conductor surfaces intensifies the field and is the mechanism for corona discharges, each of which causes a burst of noise. Audible noise is generally considered insignificant for lines operating at or below 345 kV.

Audible noise levels have typically been reported only for points farther away from the transmission lines than would be expected for occupational exposures. Estimates of noise exposures based on theory give levels lower than minimal levels estimated to cause hearing loss. Although other health effects of noise have been claimed, there are no good data to suggest that these effects have occurred at the occupational exposure levels estimated from theory. The occupational noise exposure from these high-voltage transmission lines can be an annoyance, however, interfering with conversation in the vicinity of the lines and possibly constituting a safety hazard.

Information is particularly lacking for direct current (dc) lines. Witwer et al. (1978) concluded, however, that audible noise hazards to workers near high-voltage dc lines are no greater, and probably less, than hazards to workers at an equal distance from high-voltage ac lines of equivalent voltage and power capacities.

Electric Shocks

The following classes of currents are often experienced in occupational exposures to transmission lines (Witwer et al., 1978):

Polarizing or charging currents (displacement currents) that flow through a person in contact with a conducting object in the vicinity of an ac transmission line, or in contact with an ac conductor in hot-line work.

Ion currents generated in dc transmission line fields. These ion currents can result in a buildup of charge on a worker insulated from ground, which will be discharged when contact is made with a well-grounded object.

Shock currents of small magnitude received from touching large metal objects that are in the fields of the transmission line or switchyard. These shock currents may be sufficient to startle a worker.

Shock currents received when a person completes a high-voltage circuit capable of delivering substantial current through a person. The victims of such accidents are likely to require medical attention.

Very little information is available on measurements of currents experienced as part of occupational exposure to high-voltage transmission lines, presumably due the number of practical difficulties involved in measuring these currents. The principal potential health effects of shocks, i.e., respiratory arrest, ventricular fibrillation, and thermal and electrical burns, are severe and often fatal. Other effects include temporary soreness and weakness of muscles and injuries secondary to falls resulting from a startled reaction to the shock. Potential chronic health effects caused by exposures to repeated low-level electric shocks or by exposures to the electromagnetic fields themselves are discussed in the following section.

High-Intensity Electromagnetic Fields

Little information is available about field levels in occupational exposures to high-voltage transmission lines. Witwer et al. (1978) has suggested the following classes of exposure to electromagnetic fields:

Uniform electric fields under a transmission line or in a switchyard while wearing non-conducting clothing and shoes that insulate the worker from the earth.

Highly spatially varying electric fields while in a Faraday cage, on a transmission line tower, in a bucket working close to the surface of a conductor, or in the vicinity of a large metal object such as a work vehicle.

Exposure to magnetic fields. The magnetic fields of the lines and switchyard are less disturbed than electric fields by the presence of people and other non-magnetic objects. These fields are highest at the surface of the conductor, and decrease as the distance from the line increases.

Among the problems are that the field is affected by whether the worker is near or in contact with conducting objects, and that field strengths can vary considerably over different parts of a worker's body depending upon such factors as type of clothing (conducting/insulating) and grounding.

It appears that electric and magnetic fields probably exert biological effects on many animal species; however, many of these effects occur at field strengths too low to involve significant transfer of energy, and none have involved field strengths as strong as peak occupational exposures. Whether or not the biological effects of these fields have significance for the health of workers exposed to them is debatable. The reported biological effects of low-frequency electromagnetic fields that have potential significance for human occupational health and safety are summarized in Table 2.

Table 2. Reported Biological Effects of Low-Frequency Electric and Magnetic Fields that have Potential Significance for Human Occupational Health and Safety (Witwer et al., 1978).

Species	Field Strength	Results	Reference
<u>Effects on formed elements of blood</u>			
Human	7-14 kV/m	Increases and decreases in lymphocytes, neutrophilic leukocytes, and thrombocytes; changes in erythrocyte shape	Asanova and Rakov, 1966
Human	~70 kV/m	No significant changes in formed elements of blood	Kouwenhoven <u>et al.</u> , 1967; Singlewald <u>et al.</u> , 1973
Human	1-20 kV/m	Leukocytosis, neutrophilic leukocytosis, reticulocytosis	Hauf, 1974
Mice, Rats	100 kV/m	Increase in percentage of neutrophils and eosinophils	Blanchi, 1973
<u>Effects on nervous system, performance and behavior</u>			
Human	7-14 kV/m	Subjective complaints, headache, fatigue, sleepiness, GI disorders, sexual dysfunction	Asanova and Rakov, 1966
Human	7-14 kV/m	Changes in autonomic function; changes in reaction time to stimuli; changes in neuromuscular response	Sazonova, 1967
Human	1-20 kV/m	No effect on pulse rate, blood pressure, reaction time to stimuli, EEG, and EKG	Hauf, 1974; Hauf and Weisinger, 1973
Human	~70 kV/m	No effect on hearing, vision, EEG, and EKG; psychiatric examination negative	Kouwenhoven <u>et al.</u> , 1967; Singlewald <u>et al.</u> , 1973
Human	4 V/m (2-12 Hz)	Increase in reaction time to auditory signal; decrease when frequency of field increased	Hamer, 1968
Human	1-2 V/m (3 Hz) (10 Hz)	Increase in reaction time to visual stimulus; change in galvanic skin response; decrease in reaction time	Konig, 1974

Table 2. Reported Biological Effects of Low-Frequency Electric and Magnetic Fields that have Potential Significance for Human Occupational Health and Safety (Witwer et al., 1978). (Cont'd)

Species	Field Strength	Results	Reference
Human	20 kV/m	No effect on psychological performance and reaction time tests	Johansson <u>et al.</u> , 1973
Human	Unknown (60 Hz)	Anecdotal material on humans especially sensitive to electric fields	Wieske, 1963
<u>Effects on blood biochemistry</u>			
Human	1 G mag. (45 Hz)	Increase in blood triglycerides; no effect on behavior or performance	Beischer <u>et al.</u> , 1973
Rats	200 G mag. (50 Hz)	Increase in 11-OH-corticosteroid content of adrenal glands	Udintsev and Moroz, 1974
Rats	15 kV/m (60 Hz)	Increase in serum protein and albumin, decrease in serum corticosterone	Marino <u>et al.</u> 1974; 1976a; 1976b
Squirrel Monkeys	200 G mag. (dc)	Increased excretion of 17-OH corticosteroid hormones in urine	Friedman and Carey, 1972
<u>Effects on general health and well-being</u>			
Human	7-14 kV/m	Neural pathology, cardiovascular disease, gastritis, colicystitis	Asanova and Rakov, 1966
Human	~70 kV/m (60 Hz)	No significant pathology	Kouwenhoven <u>et al.</u> , 1967; Singlewald <u>et al.</u> , 1973
Human	Unknown	No medical or health effects from living near 50 Hz power lines	Strumza, 1970
<u>Effects on reproduction, mutation, and cancer</u>			
Human	7-14 kV/m	"Sexual weakness" reported	Asanova and Rakov, 1966
Human	~70 kV/m	Occasional low sperm counts	Kouwanhoven <u>et al.</u> , 1967; Singlewald <u>et al.</u> , 1973

Table 2. Reported Biological Effects of Low-Frequency Electric and Magnetic Fields that have Potential Significance for Human Occupational Health and Safety (Witwer et al., 1978) (Cont'd)

Species	Field Strength	Results	Reference
Fruit flies	20 V/m and 2 G (45 and 75 Hz)	Mutations	Coate, 1970
Fruit flies	10 V/m and 1 G (45, 60, 75 Hz)	No mutations	Mittler, 1972
<u>E. coli</u>	20 V/m and 2 G (45 and 75 Hz)	No mutations observed	Coate, 1970
Human	Unknown (60 Hz)	Higher than expected proportional mortality ratio for lymphosarcoma	Goldsmith and Guidotti, 1977

In general, the reported effects suggest that electromagnetic fields or ions in the atmosphere may have some effect on the nervous or neuroendocrine system of mammals, including man. Although there is no evidence that electric fields have any effects on reproduction, mutation, or cancer incidence, questions about these possible hazards arouse unusual public interest, and were reviewed by Witwer et al. (1978).

Studies of American linemen found occasional low sperm counts (Kouwenhoven et al., 1967; Singlewaid et al., 1973), which the authors attributed to normal variations in sexual habits. Linemen in the USSR complained of "sexual weakness" (Asanova and Rakov, 1966), but the term was not defined. Mice exposed to 60 Hz electric fields showed no difference in fertility or breeding performance from controls (Knickerbocker et al., 1967).

There has been a report that a low-level, combined electric and magnetic field induced mutations in Drosophila melanogaster (Coate, 1970). A later study (Mittler, 1972) failed to confirm this effect and attributed Coate's positive finding to faulty experimental technique. Tests for mutation in E. coli were negative (Coate, 1970).

There are no reliable reports of cancer induction by electric fields, though there are a few reports on cancer treatment by magnetic fields. In a study of the proportional mortality ratio for lymphosarcoma (Goldsmith and Guidotti, 1977), the ratio for linemen was 194; however, it was based on only 6 observed deaths.

A number of studies have indicated that electric currents have the potential for stimulating cell proliferation and tissue growth. Most of the studies have involved implanted electrodes delivering currents to the tissues in particular patterns, but there is no evidence that electric fields under ordinary

circumstances have any effect on the proliferation of either normal or malignant cells in vivo.

Whether electromagnetic field effects on humans are harmful or not is undeterminable, but current evidence does not indicate that power system workers suffer ill effects from exposure to relatively high electric fields. The reported neurological and behavioral effects in animals (including man) do not appear to be harmful or objectionable, although a change in human reaction time might, in some cases, contribute to the likelihood of industrial accidents. This judgement is supported by the results of a recently published epidemiologic study of 53 workers with greater than 5-year exposures to the electric field (predominately 0-10 kV/m exposures) of 400 kV substations. Knave et al. (1979) found no differences between exposed and reference groups as a consequence of the exposures when the nervous system (neurasthenic symptoms, psychological tests, electroencephalography), the cardiovascular system (symptoms, blood pressure, electrocardiography), blood (hemoglobin, red blood cells, reticulocytes, white blood cells including differential count, thrombocytes, sedimentation rate), and fertility were assessed.

VIII. PERTINENT NIOSH PUBLICATIONS

No relevant NIOSH publications were encountered.

IX. EXISTING STANDARDS

No data were encountered.

X. EXPOSURE ESTIMATES

As detailed in Section III, 320,000 workers were employed in 3622 electric power generating plants in 1977 (Anon., 1978a); of this total 262,000 workers were involved in production.

XI. ONGOING STUDIES

No relevant ongoing studies were identified.

REFERENCES

- Anon. (1972) Standard Industrial Classification. Office of Management and Budget.
- Anon. (1977a). National Electric Safety Code, 1977 Edition. American National Standards.
- Anon. (1977b). Preliminary Tests of Physacoustic Facilities on Technology for a Study of Transmission Line Audible Noise. Division of Electric Energy Systems, Department of Energy (December 1977).
- Anon. (1978a). Statistical Abstracts of the United States, 1978. U.S. Department of Commerce.
- Anon. (1978b). Common Record Hearings on Health and Safety of Extra-High Voltage Transmission Lines. New York State Public Service Commission (June 19, 1978).
- Anon. (1978c). Biological Effects of High Strength Electric Fields on Small Animals. Department of Energy, Division of Electric Energy Systems (April, 1978).
- Anon. (1979a). Occupational Injuries and Illnesses in the U.S. by Industry, 1976. U.S. Department of Labor Bulletin, No. 2019 (April 1979).
- Anon. (1979b). Transmission Line Reference Book-345 kV and above. Electric Power Research Institute (June 1979).
- Asanova, T.P., and A.I. Rakov (1966) The state of health of persons working in electric fields of outdoor 400 and 500 kV switchyards. Gig. Tr. Prof. Zabol 5. (Transl. pubd. in Special Publ. #10. IEEE Power Engineering Society, Piscataway, N.J.)
- Beischer, D.E., J.D. Grisett, and R.E. Mitchell (1973) Exposure of man to magnetic fields alternating at extremely low frequency. Naval Aerospace Medical Research Laboratory, Pensacola, Fla. NAMRL-1180. (Available from NTIS: AD770140.)
- Blanchi, D. (1973) Exposure of mammals to strong 50 Hz electric fields. Part 1. Effects on the proportion of the different leukocyte types. Arch. Fisiol., 70:50.
- Coate, W.B. (1970) Project biological effects test program. Pilot studies. Final report. (Available: NTIS AD717408.)
- Friedman, H., and R.J. Carey (1972) Biomagnetic stressor effects in primates. Physio. Behav., 9: 171-3.
- Goldsmith, J.R., and T.L. Guidotti (1977) Environmental factors in the epidemiology of lymphosarcoma. In: S.C. Sommers and P.P. Rosen, eds., Pathology Annual. Part 2. Appleton-Century-Crofts, New York.

- Hamer, J.R. (1968). Effects of low-level, low-frequency electric fields on human reaction time. *Comm. Behav. Biol., Part A*, 2:217.
- Hauf, R. (1974) Effects of 50 Hz alternating fields on man. *Electrotechnische Zeitung--b*, 26: 318-20.
- Hauf, R., and J. Wiesinger (1973) Biological effects of technical electric and electromagnetic fields. *Int. J. Biometeor.*, 17: 213-15.
- Johansson, R., A.G. Lindquist, S. Lindquist, and V. Scuka (1973) Is there a connection between the electricity in the atmosphere and the function of man? Part 3. 50 Hz field variations. Forvarets Forskningsanstalt Aduelning. 2: FOA Report C-2627-H5.
- Knave, B., F. Gamberale, S. Bergstrom, E. Birke, A. Iregren, B. Kolmodin-Hedman, and A. Wennberg (1979) Long-term Exposure to Electric Fields. *Scan. J. Environ. Health*, 5: 115-25.
- Knickerbocker, G.E., W.B. Kouwenhoven, and H.C. Barnes (1967). Exposure of mice to a strong ac electric field--an experimental study. *IEEE Trans. Pow. App. Sys.* 86:498-505.
- Konig, H.L. (1974) Behavioral changes in human subjects associated with ELF electronic fields. In: M. Persinger, ed., *ELF and VLF electromagnetic field effects*. Plenum Press, New York.
- Kouwenhoven, W.B., O.R. Langworthy, M.L. Singlewald, and G.C. Knickerbocker (1967) Medical evaluation of man working in ac electric fields. *IEEE Trans. on Power Apparatus and Systems.*, 86: 506-11.
- Marino, A.A., R.O. Becker, and B. Ullrich (1976a) The effect of continuous exposure to low-frequency electric fields on three generations of mice: a pilot study. *Experientia.*, 32: 565-6.
- Marino, A.A., T.J. Berger, B.P. Austin, R.O. Becker, and F.X. Hart (1976b) Evaluation of electrochemical information transfer systems. Part I. Effects of electric fields on living organisms. *J. Electrochem. Soc.*, 123: 1199-1200.
- Marino, A.A., T.J. Berger, J.T. Mitchell, B.A. Duhacek, and R.O. Becker (1974) Electric field effects in selected biologic systems. *Ann. N.Y. Acad. Sci.*, 238: 436-44.
- Marks' Standard Handbook for Mechanical Engineers (1978). 8th ed. Baumeister, T., Avallone, E.A., and Baumeister, T., III, editors. New York: McGraw-Hill Book Co.
- Mittler, S. (1972) Low-frequency electromagnetic radiation and genetic aberrations. Final report. (Available: NTIS AD749959.)

- Sazonova, T.E. (1967) Physiological and hygienic assessment of labor conditions at 400-500 kV outdoor switchyards. Scientific Pubs., Inst. of Labor Protection of the All-Union Central Council of Trade Unions, Issue 46. (Trans. pub. in Special Publ. #10. IEEE Power Engineering Society, Piscataway, N.J., 1975.)
- Schwartz, L.H. of Stone and Webster Engineering Co. (1979). Personal letter to Arnold Hanchett, September 1979.
- Singlewald, M.L., O.R. Langworthy, and W.B. Kouwenhoven (1973) Medical follow-up study of high voltage linemen working in ac electric fields. IEEE Trans. on Power Apparatus and Systems., 92: 1307-9.
- Standard Handbook for Electrical Engineers (1968). 10th ed. Fink, D.G. and Carroll, J.M., editors. New York: McGraw-Hill Book Co.
- Strumza, M.V. (1970) Influence of proximity to high tension electric lines on human health. Arch. Mal. Prof., 31: 269-76.
- Udintsev, N.A., and V.V. Moroz (1974) Reaction of the hypophyseal-adrenal system to the action of a variable magnetic field. Byull, Exsp. Biol. Med., 76(6): 51-3.
- Wieske, C.W. (1963) Human sensitivity to electric fields. In: F. Alt, ed., Biomedical Sciences Instrumentation. Vol. 1. Plenum Press, N.Y.
- Witwer, C.R., S.D. Kaplan, B.L. Scott-Walton, J.S. Krebs, and J.R. Young (1978) Occupational Safety and Health Effects of High-Voltage Transmission Lines. Report prepared for NIOSH by the Center for Occupational and Environmental Safety and Health, SRI International (November 1978), Contract No. 210-77-0031.
- Zaffanella, L.E., and D.U. Deno (1978) Electrostatic and Electromagnetic Effects of Ultrahigh-Voltage Transmission Lines. Prepared by General Electric Company for the Electric Power Research Institute (June 1978).

Appendix A

(Anon., 1972)

Major Group 49.—ELECTRIC, GAS, AND SANITARY SERVICES

The Major Group as a Whole

This major group includes establishments engaged in the generation, transmission and/or distribution of electricity or gas or steam. Such establishments may be combinations of any of the above three services and also include other types of service such as transportation, communication, and refrigeration. Water and irrigation systems, and sanitary systems engaged in the collection and disposal of garbage, sewage, and other wastes by means of destroying or processing materials, are also included. Establishments engaged in such operations as manufacturing ice and retail sale of appliances are classified elsewhere. If one service of a combination system does not constitute 95 percent or more of revenues, the establishment should be classified as a combination in Group 493, with the subgroup being determined by the major service supplied.

Group No.	Industry No.	
491		ELECTRIC SERVICES
	4911	Electric Services Establishments engaged in the generation, transmission and/or distribution of electric energy for sale. Electric power generation, transmission, or distribution
492		GAS PRODUCTION AND DISTRIBUTION
	4922	Natural Gas Transmission Establishments engaged in the transmission and/or storage of natural gas for sale. Natural gas storage Natural gas transmission
		Pipe lines, natural gas.
	4923	Natural Gas Transmission and Distribution Establishments engaged in both the transmission and distribution of natural gas for sale. Natural gas transmission and distribution
	4924	Natural Gas Distribution Establishments engaged in the distribution of natural gas for sale. Natural gas distribution
	4925	Mixed, Manufactured or Liquefied Petroleum Gas Production and/or Distribution Establishments engaged in the manufacture and/or distribution of gas for sale, including mixtures of manufactured with natural gas. Establishments distributing liquefied petroleum (LP) gas in steel containers are classified in Industry 5984. Blue gas, carbureted: production and distribution Coke oven gas, production and distribution Coke ovens, byproduct: operated for manufacture or distribution of gas Gas, mixed natural and manufactured: production and distribution Liquefied petroleum (LP) gas, distribution through mains Manufactured gas production and distribution
493		COMBINATION ELECTRIC AND GAS, AND OTHER UTILITY SERVICES Establishments providing electric or gas services in combination with other services. Establishments are classified here only if one service does not constitute 95 percent or more of revenues.

APPENDIX B

CHEMICALS AND PHYSICAL AGENTS FREQUENTLY ENCOUNTERED IN ELECTRIC
POWER GENERATION, TRANSMISSION OR DISTRIBUTION OPERATIONS

The following list was derived from a National Occupational Health Survey of
eight SIC 4911 facilities.

<u>Facility #</u>	<u>Years in Operation</u>	<u>Payroll</u>	<u>No. of Employees in Work Area</u>
003022	23	683	606
018044	37	46	46
027044	28	28	28
033072	16	33	23
041066	62	98	86
060067	1	1771	852
061057	22	115	100
066099	22	616	475

<u>Chemical</u>	<u>Total Exposures</u>
Acetone	475
Alcohol	253
Aliphatic Hydrocarbons	577
Alkanes	309
Alkenes	468
Alkyd Resins	67
Alkyl Styrene Polymers	217
Aluminum Oxide	139
Aluminum Stearate	374
Amines	215
Ammonia	282
Ammonium Chloride	52
Ammonium Hydroxide	76
Aniline	99
Antimony	117
Antimony Sulfide	117
Aromatic Hydrocarbons	583
Asbestos	66
Asphalt	57
Barium Petroleum Sulfonate	504
Barium Phenate	217
Barium Sulfate	52
Benzene	87
Beryllium Oxides	57
Butanol	82
Butanone, 2-	138
Butyl Acetate	83
Cadmium Oxides	186
Calcium Petroleum Sulfonate	504

APPENDIX B (Cont'd)

<u>Chemical</u>	<u>Total Exposures</u>
Calcium Soap	373
Carbon Monoxide	111
Carbon Tetrachloride	80
Cellulose, Nitrate	327
Chlorinated Paraffin Wax	149
Chlorine	55
Chloroprene	286
Chromic Acid (H_2CRO_4), Zinc Salt (1:1)	74
Chromium Oxides	194
Continuous Noise	358
Cresol	395
Cresol, 2,6-Di-Tert-Butyl-, p-	149
Cyclic Hydrocarbons	468
Cyclohexane	106
Cyclopentane	104
Degreaser	285
Dichlorobenzene	98
Dichlorodifluoromethane	191
Dichloroethane, 1,2-	102
Dichloromethane	199
Dichlorotetrafluoroethane	57
Diethanolamine	69
Diphenylamine	149
Dyes	216
Epoxy Resins	60
Ethanol, 2-Butoxy-	152
Ethyl Acetate	313
Ethyl Alcohol	431
Ethyl Ether	282
Ethylene, Trichloro-	504
Fatty Acid Glycerides	303
Fatty Acids	384
Fatty Oils	180
Ferrous Sulfide	117
Glycols	407
Graphite	451
Heptane	106
Hexane	410
Infrared Radiation	302
Inorganic Zinc Compounds	287
Iron Oxides	147
Isopropyl Alcohol	461
Lead	117
Lead Naphthenate	149
Lead Soap	287
Lubricant	1,753

APPENDIX B (Cont'd)

<u>Chemical</u>	<u>Total Exposures</u>
Mercury Oxides	66
Mineral Oil	1,414
Molybdenum Disulfide	392
Naphtha	246
Nickel Oxides	184
Nitrogen Oxides	111
Petroleum Spirits	1,351
Phosphoric Acid	186
Phosphoric Acid, Tritolyl Ester	478
Plasticizer	253
Polybutene	253
Polymethacrylate Resin	218
Potassium Dichromate (VI)	112
Potassium Soap	380
Potential Continuous Noise	203
Resins, Synthetic	72
Rust Inhibitor	225
Silicones	326
Solvent	1,053
Tetrachloroethylene	135
Tetraethyl Lead	104
Tetramethyl Lead	104
Thallium Oxides	57
Titanium Oxide	604
Toluene	629
Tributyl Phosphate	303
Trichloroethane, 1,1,1-	569
Tungsten Oxides	127
Ultrasonic Noise	17
Ultraviolet Radiation	212
Vinyl Chloride	286
Welding Gases, Gas	145
Xylene	647
Zinc Dialkyldithiophosphate	218