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Authors
Paxman, Dalton G
Robinson, James C

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Regulation of Occupational Carcinogens under OSHA's Air Contaminants Standard

DALTON G. PAXMAN AND JAMES C. ROBINSON[1]

Center for Occupational and Environmental Health, School of Public Health, University of California, Berkeley, California 94720

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We compare the information used by the Occupational Safety and Health Administration (OSHA) to regulate carcinogens under its 1989 Air Contaminants Standard to publicly available information on substances with potential carcinogenic activity. Carcinogenicity evaluations were obtained from the National Institute for Occupational Safety and Health (NIOSH), the American Conference of Governmental Industrial Hygienists (ACGIH), the National Toxicology Program (NTP), the Environmental Protection Agency (EPA), and the International Agency for Research on Cancer (IARC). We focus on three sets of substances: those which were regulated as carcinogens by OSHA in the Standard, those which were included in the Standard but whose exposure limits are based on noncarcinogenic effects, and those substances designated as potential carcinogens by NIOSH, ACGIH, and/or NTP but which were excluded from the Standard. The data indicate that OSHA relied almost exclusively upon the recommendations of the nongovernmental ACGIH to the exclusion of IARC and the three governmental bodies. Given their statutory authority to evaluate chemical carcinogenicity for regulatory agencies such as OSHA, the exclusion of NIOSH and NTP is particularly striking.

The Air Contaminants Standard promulgated in 1989 by the Occupational Safety and Health Administration (OSHA) covered 428 chemicals with a broad array of adverse health effects, including cancer. Potentially, this standard could have significantly reduced the number of occupationally induced illnesses and set a precedent for future regulation on a generic basis. Questions have arisen, however, concerning the process by which OSHA selected the substances to be regulated and the levels to be established as permissible exposure limits (PELs). Especially controversial has been OSHA's extensive reliance upon the threshold limit values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH) and the relative neglect of the recommendations of scientific bodies such as the National Institute for Occupational Safety and Health (NIOSH).

[1] To whom correspondence should be addressed.

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In this paper, we investigate the role that the recommendations from outside scientific organizations played in OSHA's Air Contaminants Standard. Our analysis compares the data used by OSHA in developing the Standard to the available scientific data on chemical carcinogenesis. Particular emphasis is placed on the recommendations available to OSHA from NIOSH, ACGIH, and the National Toxicology Program (NTP), the leading scientific organizations in occupational health. We analyze separately three categories of substances known or suspected to cause cancer in humans: (1) substances regulated in the Air Contaminants Standard as carcinogens; (2) substances covered by the Air Contaminants Standard which have been designated as carcinogens by NIOSH, ACGIH, and/or NTP, but whose PELs were based on noncarcinogenic effects, and (3) substances designated as occupational carcinogens by NIOSH, ACGIH, and/or NTP, but which OSHA excluded from the Air Contaminants rulemaking. For each of 132 substances, we present the evaluations by NIOSH, ACGIH, and NTP plus those of the Environmental Protection Agency (EPA) and the International Agency for Research on Cancer (IARC). Finally, we analyze the effects of OSHA's reliance upon ACGIH and exclusion of other scientific organizations and present our conclusions.

CLASSIFYING WORKPLACE CARCINOGENS

Recommendations from Authoritative Bodies

Under the Occupational Safety and Health Act, OSHA is given the mandate to set standards for control of workplace hazards but must consider recommendations from other governmental agencies (Mintz, 1984). Many scientific organizations evaluate information on potential hazards from chemical exposures. For workplace carcinogens, NIOSH, ACGIH, and NTP have historically provided OSHA with their scientific judgment in regulatory rulemaking. To a lesser extent, IARC and EPA have also contributed to the evaluation of toxic substances encountered in the workplace. These organizations have considerable cancer expertise and all publish (or make available) documents identifying potentially cancer-causing substances. The peer review process by which carcinogens are evaluated at NIOSH, NTP, EPA, and IARC ensures that the health effects data are examined by panels of experts who form a consensus opinion on the carcinogenicity of the substance (Oleinick *et al.,* 1988). In contrast, a more private system is used by the ACGIH (NIOSH, 1988b). The ACGIH does, however, include among its members many leaders in industrial hygiene (Corn, 1990).

Carcinogen Classification Schemes

The major scientific organizations possess different categorization systems for evaluating carcinogenic potential. Whereas these organizations all use epidemiological data as evidence of carcinogenicity, they differ in their reliance on animal data. Each organization also has its own set of criteria by which it determines whether the human or animal data are "sufficient" or "limited." Table 1 summarizes the weight-of-the-evidence classification schemes of the five organizations. The published documentation of NIOSH, ACGIH, and NTP does not differentiate between substances possessing

TABLE 1

SUMMARY OF THE CLASSIFICATION SCHEMES FOR OCCUPATIONAL CARCINOGENS[a]

Evidence	NIOSH	ACGIH	NTP	EPA	IARC
Human					
Sufficient	*	A1	++	A	1
Limited	*	A2	+	B1	2A
Animal					
Sufficient	*	A2	+	B2	2A/2B[b]
Limited	*	—	—	C	2B
Insufficient	—	—	—	D	3
No evidence	—	—	—	E	4
Not evaluated	—	—	—	—	—

[a] *, Potential occupational carcinogen; ++, known human carcinogen; +, reasonably anticipated to cause cancer.

[b] Depending on presence (2A) or absence (2B) of limited human data.

either insufficient or no evidence of carcinogenicity and substances not evaluated for carcinogenicity; we therefore have used the same symbol (—) for these substances. Elsewhere, the differences of the various systems are discussed in greater detail (OTA, 1987; Matula and Somers, 1989).

Each classification system uses different descriptor titles for each group of carcinogens; unfortunately, the titles have not been coordinated and create confusion when comparing the systems. To avoid this confusion, we will describe carcinogens in this paper as being either *confirmed* or *possible.* Confirmed carcinogens are substances classified in Groups A1, A, and 1 by ACGIH, EPA, and IARC, respectively, and as "known human carcinogens" by NTP. Possible carcinogens are substances classified in the following groups: A2 by ACGIH; B1, B2, and C by EPA; 2A and 2B by IARC; and as "reasonably anticipated to cause cancer" by NTP. Since the classification system of NIOSH does not distinguish between substances based on the weight of evidence, we will also classify as possible carcinogens those substances which NIOSH considers to be potential occupational carcinogens. We will use the term *potential carcinogen* in reference to substances classified in our study as being either confirmed or possible carcinogens.

Comparing Recommendations to OSHA's Regulations

We analyzed the published scientific literature and public testimony by these scientific bodies on carcinogens encountered in the workplace. For substances that were included in the Air Contaminants Standard but not regulated as carcinogens, and for substances excluded from the Standard, we present evaluations by all five scientific organizations: NIOSH, ACGIH, NTP, EPA, and IARC. The sources of documentation used in this study were all available to OSHA at the time the Standard was promulgated.

For the substances included in the ruling, OSHA published the final PEL in the *Federal Register* (OSHA, 1989). The rationale for the action on the carcinogens and their quantitative risk assessments are presented in the preamble to the Standard. In

addition, we examined the transcripts of OSHA's public hearing on the Standard, held July and August 1988, which are available to the public in the OSHA docket office in Washington, DC (OSHA, 1988). Written material that was submitted by OSHA both before and after the hearing is also included in the docket.

The various NIOSH recommendations for OSHA's use in promulgating standards are summarized in the *Morbidity and Mortality Weekly Report* (NIOSH, 1988a). In addition to the published documents, we evaluated the written testimony and extensive material submitted by NIOSH at OSHA's public hearing on the Air Contaminants Standard (NIOSH, 1988b; OSHA, 1988). As a matter of policy, information presented at hearings always includes the current NIOSH position concerning the particular hazard (NIOSH, 1988a).

We examined the published material of ACGIH. The threshold limit values are published annually by the Chemical Substance TLV committee of the ACGIH (ACGIH, 1987a). The supporting documentation for the TLVs are published and yearly addenda are released to update the documentation (ACGIH, 1987b).

For the NTP evaluations, we examined the NTP's *Fourth Annual Report on Carcinogens* (DHHS, 1985). Because the NTP does not consider occupational exposure in deriving its report, we used an analysis by the Office of Technology Assessment (OTA), in which a subset of the NTP-listed carcinogens was identified using data on occupational exposure in the United States (OTA, 1987). OTA included carcinogens on this list using two criteria: (1) inclusion in the NTP annual report and (2) detection in either of two nationwide workplace exposure surveys conducted by NIOSH (the 1972–1973 National Occupational Exposure Survey and the 1981–1982 National Occupational Hazard Survey), and/or annual production levels of greater than one million pounds (OTA, 1987). This approach excludes those NTP-listed carcinogens to which there are no significant workplace exposures.

We obtained information for the degree-of-evidence designations by the Environmental Protection Agency (EPA) from two sources within the EPA Office of Health and Environmental Assessment. To adjust reportable quantities under the Comprehensive Emergency Response, Compensation, and Liability Act, EPA developed a hazard ranking methodology for potential carcinogens involving the qualitative evaluation of the strength of the available data from human and animal studies (EPA, 1988). Additional carcinogen information was obtained from an electronic on-line database, the Integrated Risk Information System (IRIS) (EPA, 1989), which was made available to the public in 1988. The IRIS database provides continuously updated quantitative risk values and qualitative health effects information. Degree-of-evidence designations for carcinogens were obtained from IARC, which has published a review of its monographs evaluating the carcinogenic risks of individual chemicals (IARC, 1987).

We focus on the chemicals designated as potential human carcinogens by the three organizations with primary responsibility for evaluating occupational carcinogens: NIOSH, ACGIH, and NTP. For those substances regulated under the Air Contaminants Standard based on carcinogenic effects, we present the OSHA PEL, the ACGIH TLV, and the ratio of the PEL to the TLV. For confirmed or possible human carcinogens that are regulated under the Air Contaminants Standard based solely on noncarcinogenic effects, we present the carcinogenicity evaluations by NIOSH, ACGIH, NTP, and, in addition, EPA and IARC. Substances classified by EPA and/or IARC as po-

tential carcinogens but which are not classified as such by NIOSH, ACGIH, or NTP are excluded from the analysis on the grounds that they are unlikely to be present in significant quantities in the U.S. workplace. We then present carcinogenicity evaluations by the five scientific bodies for those substances designated by NIOSH, ACGIH, and/or NTP as potential carcinogens but which were excluded altogether from the Air Contaminants Standard and not covered by other OSHA regulations.

REGULATING WORKPLACE CARCINOGENS

OSHA's Air Contaminants Standard

Table 2 presents the OSHA PEL, the ACGIH TLV, and the ratio of the PEL to the TLV for 11 substances regulated under the Air Contaminants Standard based on the "avoidance of cancer." The PELs for acrylamide, carbon tetrachloride, chloroform, dimethyl sulfate, 2-nitropropane, and perchloroethylene were reduced from the former PEL, while that for *o*-toluidine remained unchanged. PELs were newly established for four substances that had not been previously regulated: amitrole, *p*-toluidine, vinyl bromide, and vinyl cyclohexene dioxide. For 7 of the 10 new PELs, the OSHA PEL was set equal to the ACGIH TLV. The ratios of the PEL to the TLV for carbon tetrachloride, chloroform, and perchloroethylene were 0.4, 0.2, and 0.5, respectively. The PEL for *o*-toluidine remained unchanged at 2.5 times the TLV.

OSHA determined that sufficient data existed to perform quantitative risk assessments for 6 of the 11 substances in Table 2. OSHA also presented an assessment performed by an outside consultant for one additional substance, perchloroethylene. The maximum likelihood estimate (MLE) of the remaining risk of cancer from exposure at the new PELs ranged from 0.27 cancers per 1000 workers for chloroform

TABLE 2

SUBSTANCES FOR WHICH OSHA SET PERMISSIBLE EXPOSURE LIMITS IN THE AIR CONTAMINANTS STANDARD BASED ON THE AVOIDANCE OF CANCER

Substance	OSHA PEL (mg/m^3)	ACGIH TLV (mg/m^3)	PEL/TLV
Acrylamide	0.03	0.03	1
Amitrole	0.2	0.2	1
Carbon tetrachloride	12	30	0.4
Chloroform	10	50	0.2
Dimethyl sulfate	0.5	0.5	1
2-Nitropropane	35	35	1
Perchloroethylene	170	335	0.5
o-Toluidine	22.5	9	2.5
p-Toluidine	9	9	1
Vinyl bromide	20	20	1
Vinyl cyclohexene dioxide	60	60	1

Note. The PELs and TLVs are 8-hr time-weighted averages for all substances except for 2-nitropropane, which has ceiling values.

to 40 cancers per 1000 workers for vinyl bromide. The MLE for exposure to *o*-toluidine at the PEL was 0.137 cancers per 1000 workers, which was determined to be an insignificant risk by OSHA. For this reason, the PEL for *o*-toluidine was not lowered, despite the lower TLV.

Table 2 does not present carcinogenicity evaluations for the 11 substances, but these can be summarized easily. All substances regulated under the Air Contaminants Standard as carcinogens were designated by NIOSH as potential human carcinogens. All except amitrole and perchlorethylene were classified as confirmed or possible carcinogens by ACGIH. NTP listed amitrole, carbon tetrachloride, chloroform, dimethyl sulfate, 2-nitropropane, and *o*-toluidine as possible carcinogens. All substances in Table 2 except vinyl bromide and vinyl cyclohexene dioxide were listed by EPA as possible human carcinogens. IARC listed all of these substances as possible human carcinogens except *p*-toluidine and vinyl cyclohexene dioxide.

Table 3 presents 67 substances that were regulated under the Air Contaminants Standard based on their noncarcinogenic effects, but which have been designated as carcinogens by NIOSH, ACGIH, and/or NTP. For each substance, the table presents the evaluations of the strength of the evidence of carcinogenic activity as determined by the NIOSH, ACGIH, NTP, EPA, and IARC.

According to NIOSH, 65 substances in Table 3 meet the criteria established in OSHA's Generic Carcinogen Policy (OSHA, 1980) for potential human carcinogens. These compounds were either previously listed by NIOSH as carcinogens (NIOSH, 1988a) or identified as carcinogens by NIOSH during the public hearing on the Air Contaminants Standard (NIOSH, 1988b). The ACGIH considered 12 of the substances in Table 3 as confirmed or possible human carcinogens. In the *Fourth Annual Report on Carcinogens,* NTP listed 21 of these substances as potential human carcinogens. Of the 42 substances in Table 3 which it evaluated, the EPA considered 41 substances as confirmed or possible human carcinogens. IARC designated 28 of these substances as confirmed or possible human carcinogens and 21 as having insufficient evidence of carcinogenicity.

While most of the substances in Table 3 are designated as only possible human carcinogens, five are considered confirmed human carcinogens by at least one scientific organization. Benzene-soluble coal tar pitch is categorized as a confirmed human carcinogen by IARC, NTP, and ACGIH and a probable human carcinogen by EPA. Soluble or inorganic nickel is considered a confirmed human carcinogen by both EPA and IARC and a suspect human carcinogen by NTP. In addition, IARC considers hardwood dust, isopropyl alcohol manufacture, and nickel carbonyl to be confirmed human carcinogens; these substances are listed as possible carcinogens by NTP. All but 12 of the 67 substances in Table 3 are considered potential human carcinogens by at least two outside groups. Six substances were considered potentially carcinogenic by all five organizations, including benzo[*a*]pyrene, benzene-soluble coal tar pitch, 1,1-dimethylhydrazine, hydrazine, 4,4′-methylene bis(2-chloroaniline) (MBOCA), and propylene imine.

Table 4 presents 68 substances that have been designated as potential human carcinogens by NIOSH, ACGIH, and/or NTP, but which were neither included in the Air Contaminants Standard nor regulated under one of OSHA's substance-specific standards. For each substance, the carcinogenicity classification by NIOSH, ACGIH, NTP, EPA, and IARC is listed. Of these excluded substances, 26 were designated

potential human carcinogens by NIOSH, 13 by ACGIH, and 52 by NTP. EPA listed 27 substances as confirmed or possible carcinogens. IARC evaluated 53 of these substances and listed 45 as confirmed or possible human carcinogens. All except 9 of the 68 compounds were designated as potential carcinogens by at least two outside bodies. Five substances were considered potentially carcinogenic by all five organizations. Four substances in Table 4 (beryllium and compounds, chromic acid and chromates, chromyl chloride, and zinc chromate) were included by OSHA in the original proposal for the Air Contaminants rulemaking, but were considered "too complex" to be included in the final Standard (OSHA, 1989).

Eleven substances in Table 4 were considered by at least one scientific organization to be confirmed human carcinogens. Water-insoluble hexavalent chromium compounds were designated as confirmed human carcinogens by ACGIH, NTP, EPA, and IARC. Fumes and dust from nickel sulfide roasting were considered confirmed human carcinogens by ACGIH and EPA. Diethylstilbestrol was considered a confirmed carcinogen by NTP, EPA, and IARC. Chromite ore processing was designated a known carcinogenic process by ACGIH. These four substances and processes were considered by NIOSH to be potential human carcinogens. IARC considered azathioprine, 1,4-butadiol dimethyl sulfonate, chlorambucil, cyclophosphamide, hematite underground mining, melphalan, and phenacetin as confirmed human carcinogens; all of these were listed as potential carcinogens by NTP.

OSHA's Reliance upon the TLVs

The criterion by which OSHA regulated substances as carcinogens in the Air Contaminants Standard was the existence of a numerical TLV and a cancer designation by the ACGIH. In the preamble to the Standard, OSHA states:

> The ACGIH TLVs include some substances which it categorizes as carcinogens, but does not set the exposure limit based on carcinogenicity. It includes other substances which it may or may not categorize as carcinogens but for which the exposure limit is set taking into account carcinogenicity. It is only this last category which OSHA considered as carcinogens in its proposal. (OSHA, 1989)

Using this rationale, OSHA regulated 11 substances based on cancer risks. OSHA failed to designate 67 substances covered by the rulemaking as carcinogens, and excluded an additional 68 substances from the ruling altogether, despite the cancer designations from NIOSH, ACGIH, NTP, EPA, and IARC. The Air Contaminants Standard is more conservative than the ACGIH in the treatment of occupational carcinogens. Twelve of the substances regulated under the Standard based on noncarcinogenic health effects were designated as confirmed or possible carcinogens by the ACGIH (Table 3). An additional 13 substances designated as potential carcinogens by the ACGIH were excluded from the rulemaking altogether (Table 4).

For 7 of the 11 substances in Table 2 OSHA used quantitative risk assessment methods to estimate cancer risks for exposure at various concentrations. OSHA could have set PELs based on these risk assessments instead of relying so extensively on the TLVs. The reliance upon TLVs produced a wide range of residual risks at the new PELs, from 0.27 cancers per 1000 workers for chloroform to 40 cancers per 1000 workers for vinyl bromide. OSHA's justification for not lowering the PEL for *o*-toluidine

TABLE 3

CARCINOGENICITY DESIGNATION FOR 67 SUBSTANCES REGULATED IN THE AIR CONTAMINANTS STANDARD BASED ON NONCARCINOGENIC HEALTH EFFECTS

Substance	NIOSH	ACGIH	NTP	EPA	IARC
Acetaldehyde	*	—	—	B2	2B
Aldrin	*	—	—	B2	3
Aniline	*	—	—	B2	3
o-Anisidine	*	—	+	—	2B
p-Anisidine	*	—	—	—	3
Arsine	*	—	—	—	—
Benzo[*a*]pyrene	*	A2	+	B2	2A
tert-Butyl chromate	*	—	—	—	—
Captafol	*	—	—	—	—
Captan	*	—	—	B2	3
Carbon black	*	—	—	B2	3
Chlordane	*	—	—	B2	3
Chlorinated camphene (toxaphene)	*	—	+	B2	2B
Chlorodiphenyl					
42% chlorine	*	—	—	—	2A
>54% chlorine	*	—	—	B2	2A
Chromium metal	*	—	+	C	3
Chrysene	*	A2	—	B2	3
Coal tar pitch, as benzene solubles	*	A1	++	B1	1
Dichloroacetylene	*	—	—	—	3
p-Dichlorobenzene	*	—	—	C	2B
Dichlorodiphenyl-trichloroethane (DDT)	*	—	+	B2	2B
Dichloroethyl ether	*	—	—	B2	3
Dichloropropene	*	—	—	B2	2B
Dieldrin	*	—	—	B2	3
Diglycidyl ether	*	—	—	—	—
1,1-Dimethylhydrazine	*	A2	+	B2	2B
Dinitrotoluene	*	—	—	B2	—
Dioxane	*	—	+	B2	2B
Di-*sec*-octyl phthalate	*	—	+	B2	2B
Epichlorohydrin	*	—	+	B2	2A
Ethyl acrylate	*	—	—	—	2B
Ethyl chloride	*	—	—	—	—
Ethylene dichloride	*	—	—	B2	2B
Gasoline	*	—	—	B2	—
Heptachlor	*	—	—	B2	3
Hexachlorobutadiene	*	A2	—	C	3
Hexachloroethane	*	—	—	C	3
Hexamethyl phosphoramide	*	A2	+	—	2B
Hydrazine	*	A2	+	B2	2B
Isopropyl alcohol manufacture	—	—	+	—	1
Lindane	—	—	+	B2/C	—
Methyl bromide	*	—	—	D	3
Methyl chloride	*	—	—	C	3
4,4′-Methylene bis(2-chloroaniline)	*	A2	+	B2	2A

Note. Refer to Table 1 for explanation of symbols.

TABLE 3—*Continued*

Substance	NIOSH	ACGIH	NTP	EPA	IARC
Methylhydrazine	*	A2	—	—	—
Methyl iodide	*	A2	+	C	3
Nickel, soluble or inorganic	*	—	+	A	1
Nickel carbonyl	*	—	+	B2	1
p-Nitrochlorobenzene	*	—	—	C	—
Phenyl glycidyl ether	*	—	—	—	—
Phenylhydrazine	*	A2	—	—	—
Propylene dichloride	*	—	—	—	—
Propylene imine	*	A2	+	B2	2B
Propylene oxide	*	—	+	B2	2A
Rosin core solder pyrolysis products	*	—	—	—	—
Silica, crystalline	*	—	—	—	2A
1,1,2,2-Tetrachloroethane	*	—	—	C	3
Toluene-2,4-diisocyanate	*	—	+	—	2B
1,1,2-Trichloroethane	*	—	—	C	3
Trichloroethylene	*	—	—	B2	3
1,2,3-Trichloropropane	*	—	—	—	—
Uranium					
Insoluble compounds	*	—	—	—	—
Soluble compounds	*	—	—	—	—
Vinylidene chloride	*	—	—	C	3
Welding fumes	*	—	—	—	—
Wood dust					
Hardwood	*	—	—	—	1
Softwood	*	—	—	—	2B

was that its residual risk at the previous PEL, 0.137 cancers per 1000 workers, was insignificant; consequently, OSHA left the PEL at 2.5 times the TLV. OSHA rarely regulates carcinogens with predicted lifetime risks for cancer below one in a thousand (Rodericks *et al.*, 1987).

Although not a governmental organization, the ACGIH has had a significant impact on occupational health policy in this country (Ashford, 1976; Mintz, 1984; Corn, 1990). Elsewhere, we have documented that OSHA relied heavily upon the TLVs and excluded the recommendations of NIOSH and other scientific bodies in the setting of PELs based on noncarcinogenic effects (Robinson *et al.*, 1991). Most of the 400 substances, including several carcinogens, for which OSHA set PELs in 1971 under section 6(a) of the Occupational Safety and Health Act were adopted from the ACGIH TLV list (Ashford, 1976; Mintz, 1984).

A number of observers have evinced skepticism concerning the safety of the TLVs and the objectivity of the TLV-setting process. Castleman and Ziem (1988) argued that the use of unpublished data supplied by industry and the presence of industry consultants have biased the decisions of the committee to favor industrial interests. These critics found that the TLVs for 104 substances were based primarily on evidence from unpublished corporate communications. A recent analysis of the epidemiological

TABLE 4

CARCINOGENICITY DESIGNATIONS FOR 68 SUBSTANCES EXCLUDED FROM THE AIR CONTAMINANTS STANDARD AND NOT INCLUDED IN INDIVIDUAL OSHA RULEMAKINGS

Substance	NIOSH	ACGIH	NTP	EPA	IARC
Adriamycin	—	—	+	—	2A
Antimony trioxide production	—	A2	—	—	—
Benzidine-based dyes	*	—	—	—	2A
Benzotrichloride	—	—	+	B2	—
Beryllium and compounds	*	A2	+	B2	2A
Bischloroethyl nitrosourea	—	—	+	—	3
1,3-Butadiene	*	A2	+	B2	2B
1,4-Butadiol dimethyl sulfonate	—	—	+	—	1
Cadmium	*	—	+	B1	2A
Chlorambucil	—	—	+	—	1
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea	—	—	+	—	2A
Chloroprene	*	—	—	—	3
Chromic acid and chromates	*	—	—	—	—
Chromite ore processing	*	A1	—	—	—
Chromium(VI) compounds, certain water insoluble	*	A1	++	A	1
Cupferron	—	—	+	—	—
Cyclophosphamide	—	—	+	B1	1
Dacarbazine	—	—	+	—	2B
2,4-Diaminoanisole	*	—	—	—	2B
2,4-Diaminotoluene	—	—	+	B2	2B
o-Dianisidine-based dyes	*	—	—	—	—
Diesel exhaust	*	—	—	—	—
Diethyl sulfate	—	—	+	—	2A
Diethylstilbestrol	—	—	+	A	1
3,3′-Dimethoxybenzidine	—	—	+	B2	2B
3,3′-Dimethylbenzidine	*	A2	+	C	2B
Dimethyl carbamoyl chloride	*	A2	+	B2	2A
Estrogens, unconjugated	—	—	+	—	1
Ethylene thiourea	*	—	+	B2	2B
Hematite underground mining	—	—	+	—	1
Hexachlorobenzene	—	—	+	B2	2B
Hydrazobenzene	—	—	+	—	—
Iron–dextran complex	—	—	+	—	2B
Kepone	*	—	+	B2	2B
Lead chromate	*	A2	—	—	2B
Melphalan	—	—	+	B1	1
4,4′-Methylene bis(*N*,*N*-dimethyl)benzenamine	—	—	+	—	3
Methylene chloride	*	A2	—	B2	2B
4,4-Methylene dianiline	*	A2	+	B2	2B
Metronidazole	—	—	+	—	2B
Mirex	—	—	+	—	2B
Nitrilotriacetic acid	—	—	+	—	—
Nitrogen mustard	—	—	+	—	2A
2-Nitronaphthalene	*	—	—	—	—

Note. Refer to Table 1 for explanation of symbols.

TABLE 4—*Continued*

Substance	NIOSH	ACGIH	NTP	EPA	IARC
Nickel sulfide roasting fume and dust	*	A1	—	A	—
Oxymethalone	—	—	+	—	—
Phenacetin and analgesic mixtures containing phenacetin	—	—	+	B2	1
Phenazopyridine hydrochloride	—	—	+	—	2B
Phenyl-β-napthylamine	*	A2	—	—	3
Phenytoin and sodium salt of phenytoin	—	—	+	—	2B
Polybrominated biphenyls	—	—	+	—	2B
Procarbazine and procarbazine hydrochloride	—	—	+	—	2A
Propane sultone	*	A2	—	B2	2B
Propylthiouracil	—	—	+	—	2B
Reserpine	—	—	+	B2	3
Saccharin	—	—	+	—	2B
Streptozotocin	—	—	+	B2	2B
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD)	*	—	+	—	2B
Thioacetamide	—	—	+	B2	2B
Thiourea	—	—	+	B2	2B
Thorium dioxide	—	—	+	—	—
o-Tolidine-based dyes	*	—	+	—	—
2,4,6-Trichlorophenol	—	—	+	B2	—
Tris(1-aziridinyl)phosphine sulfide	—	—	+	—	3
Tris(2,3-dibromopropyl) phosphate	—	—	+	B2	2A
Urethane	—	—	+	B2	2B
Vinyl fluoride	*	—	—	—	3
Vinylidine fluoride	*	—	—	—	3

studies cited in the TLV documentation revealed that adverse effects were commonly reported at exposure levels at or below the TLV (Roach and Rappaport, 1990). These authors found that the TLVs did not correlate well with the incidence of adverse effects, but did correlate well with the exposure levels cited in the studies. Several reports have commented upon the economic feasibility for reducing exposures to TLV levels, implying that the ACGIH implicitly considers the costs and benefits of each limit (Halton, 1988; Robinson and Paxman, 1990).

CONCLUSION

Our analysis suggests that OSHA designated particular substances as carcinogens and set PELs in the Air Contaminants Standard based primarily on the recommen-

dations by the ACGIH. Despite carcinogen designations by one or more scientific bodies, many substances were regulated in the Standard based on noncancer risks or were excluded from the ruling altogether.

OSHA ignored the scientific and technical expertise of the federal research agencies, especially NIOSH and NTP, which were established to provide regulatory agencies with scientific evaluations. OSHA largely ignored the recommendations of NIOSH, despite the latter having devoted a large fraction of its staff time and resources to the rulemaking effort. OSHA also neglected carcinogen information provided by NTP, which exists to evaluate human health risks from chemical exposure. The NTP *Annual Reports* have increasingly been used to trigger regulatory requirements, including several state and community right-to-know laws and OSHA's Hazard Communication Standard (Oleinick *et al.*, 1988; Barnard *et al.*, 1989). For more informed occupational health policy, OSHA should fully utilize the available scientific expertise in its regulatory decisions.

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