VI. DEVELOPMENT OF STANDARD

Basis for Previous Standards

In 1967, the American Conference of Governmental Industrial Hygienists (ACGIH) [113] adopted a threshold limit value (TLV) of 0.2 mg/cu m for coal tar pitch volatiles (CTPV), described as a "benzene-soluble" fraction, and listed certain carcinogenic components of CTPV. The TLV was established to minimize exposure to the listed substances believed to be carcinogens, viz, anthracene, BaP, phenanthrene, acridine, chrysene, and pyrene [113]. This TLV was promulgated as a federal standard under the Occupational Safety and Health Act of 1970 (29 CFR 1910.1000). No foreign standards were found for exposure to coal tar pitch or creosote.

In 1973, NIOSH [114] published the "Criteria for a Recommended Standard--Occupational Exposure to Coke Oven Emissions," recommending work practices to minimize the harmful effects of exposure to coke-oven emissions and inhalation of coal tar pitch volatiles. In 1974, OSHA established a Standards Advisory Committee on Coke Oven Emissions to study the problem of the exposure of coke-oven workers to CTPV and to prepare recommendations for an effective standard in the assigned area. In 1975, the Committee recommended a limit of 0.2 μg/cu m for BaP (Federal Register, 41:46742-46787, October 22, 1976).

In 1976, OSHA promulgated a federal standard on coke oven emissions designed to reduce employee exposure to carcinogenic chemicals (Federal Register, 41:46742-46787, October 22, 1976). The standard was based on evidence collected from epidemiologic and animal experiments, which indicated that the chemicals present in coke oven emissions could produce skin and lung cancer in humans and animals. Cited epidemiologic studies by Doll et al [54,55], Redmond et al [50], and Reid and Buck [56] were said to have shown that employees exposed to coke oven emissions had a high risk of dying from lung and bladder cancer. Kidney cancer in coke oven workers was also reported by Redmond et al [50]. However, it was pointed out that the route by which carcinogens from coke oven emissions reached the kidney was not known. Particulate carcinogens may be absorbed after ingestion or inhalation or be absorbed through the skin. Doll et al [55] reported excess bladder cancer in British gas workers.

The incidence of skin cancer, especially on the scrotum, among coke oven workers was also considered, although there were no deaths from skin cancer [3]. Furthermore, it was stated that the incidence of skin cancer among coke oven workers was not related to the job or geographic location of workers in the coke plant. Data from several animal studies showed that repeated application of coal tar or its fractions containing BaP at 0.01% or more produced squamous-cell carcinomas in mice. It was stated that, although there were no deaths in coke oven workers from skin cancer, the possibility of a skin cancer hazard could not be dismissed. Variations in human response could be related to factors like the type of operation, the materials produced, personal hygiene, and medical surveillance. To the extent that such factors could be controlled, they were deemed appropriate for inclusion in the standard. Furthermore, OSHA also considered the increased incidence of non-malignant respiratory diseases, such as chronic bronchitis, pneumoconiosis, emphysema, and fibrosis, in promulgating the present standard.

It was concluded that coke oven emissions induced lung and genitourinary tract cancer in the exposed population. It was also concluded that coal tar products were carcinogenic to animal skin and were related to increased skin cancer mortality in human populations similar to coke oven workers. Thus, protective measures designed to reduce employee exposure to coke oven emissions were warranted. A standard for the benzene-soluble fraction of total particulate matter present during the destructive distillation or carbonization of coal was set; this standard set forth specific minimum engineering controls and work practices designed to reduce exposure to coke oven emissions.

Basis for the Recommended Standard

(a) Permissible Exposure Limits

Exposure to coal tar products (including coal tar, coal tar pitch, and creosote) in the occupational environment has been reported to affect the skin and eyes [45,46]. Leb et al [45] and Susorov [46] reported photosensitization, mild photophobia, temporary conjunctivitis, and decreased visual acuity in coal briquette loaders exposed to coal tar pitch dust. These authors [45,46] pointed out that the workers did not wear any protective clothing, special glasses, or respirators, and that fewer effects were observed in nighttime workers than in daytime workers. This 4- to 5-hour exposure to coal tar pitch dust produced upper respiratory effects in the workers, together with some decrease in visual acuity. Gibbs and Horowitz [52] found that mortality from lung cancer increased with exposure to tar in workers in aluminum reduction plants using the Soderberg processes. However, the mortality in these workers was not significantly increased when compared with the mortality in the local communities, apparently reflecting an increased rate of lung cancer in those communities.

In another study [53] of aluminum industry workers, a similar increase in lung cancer mortality was found in potroom workers using the horizontal Soderberg process. The presence of relatively high amounts of tarry substances (69.5-97 and 27-2,130 mg/cu m in plants with horizontal and vertical Soderberg process, respectively) and BaP levels (0.6-9.4 and 29-56 μg/cu m) in the air of aluminum reduction plants has also been associated with increased lung cancer mortality [51]. Doll et al [55] reported high respiratory cancer mortality in coke-oven workers. Redmond et al [50] found that coke-oven workers employed for 5 years or more had a high risk of dying from lung and kidney cancer; non-oven workers had a high risk of developing cancers of the colon, pancreas, buccal cavity, and pharynx, while byproducts workers had no increased risk of dying from any cancer [50,55,56]. From these epidemiologic studies, it is concluded that exposure to crude coal tar, coal tar pitch, and mixtures containing these substances in the occupational environment can cause lung cancer and possibly cancer of internal organs, such as the colon, pancreas, buccal cavity, and pharynx. This conclusion that exposure to coal tar causes lung cancer is supported by animal data discussed below.

Long-term exposure (1-43 years) to coal tar pitch has been reported to cause malignant tumors on the hands, face, and neck of briquette-factory workers [40]. However, the investigators did not specify the source or chemical nature of the pitch to which the workers had been exposed. Skin tumors have been reported in many studies [40,47] with so many samples that one can infer that coal tar pitches from all sources may be considered potent skin tumorigens.

Multiple skin applications of coal tar [67-69], coal tar pitch [12,69], and creosote produced skin tumors in rats and mice [63,72].

Kinkead [77] reported on the effects of aerosolized coal tar on various animal species. Mice and rats were exposed continuously for 90 days to aerosolized coal tar at concentrations of 0, 0.2, 2, 10, and 20 mg/cu m. Rabbits and hamsters were also exposed for 90 days, but only at 20 mg/cu m. Cumulative mortality of exposed animals was proportional to exposure concentration. Exposure also resulted in decreased body weights in all species tested.

McConnell and Specht [78] reported on lesions and microscopic changes in the liver, kidneys, and lungs of the animals exposed to coal tar aerosols by Kinkead [77]. In mice, the incidences of epithelial tumors at 0.2, 2, 10, and 20 mg/cu m of aerosolized coal tar were 0, 8, 37.5, and 27.8%, respectively. There were no tumors in the controls. The latent period for skin tumor development also was dose-dependent.

Sasmore [79] studied tissues from mice, rats, hamsters, and rabbits exposed to aerosolized coal tar. Lungs, liver, kidneys, spleen, lymph nodes, adrenals, bladder, and skin were examined microscopically. The incidences of lung tumors in mice exposed to coal tar at 0.2, 2, and 10 mg/cu m were 39%, 58%, and 77%, respectively. Controls had a 30% incidence of such tumors. Sasmore [79] also suggested that inhalation of aerosolized coal tar contributed to an increased incidence of lung tumors in rats at a concentration of 2 or 10 mg/cu m and of kidney tumors at 10 mg/cu m. In hamsters, a lymphosarcoma in the spleen was noted at a concentration of 10 mg/cu m; no effects were observed in any of the rabbit organs. MacEwen et al [80] showed a 100% and 82% incidence of lung tumors in male and female rats, respectively, exposed to aerosolized coal tar, intermittently for 18 months.

The data from this study [77-79] and from the study of MacEwen et al [80] show that exposure to aerosolized coal tar produced an increased incidence of lung tumors in mice and rats.

In a recent study [30] conducted by NIOSH to evaluate the health hazards of roofers exposed to coal tar pitch, 67% (23/34) of the workers examined had skin reactions such as burning sensation, irritation, and blistering. Fifty percent (17/34) had eye effects of varying severity, described as slight burning, slight conjunctival erythema, lacrimation, and swelling of the lids. Four of these workers experienced inability to close their eyes and interference with vision. Of the six workers showing clinical evidence of conjunctivitis, four were exposed to PPOM at reported concentrations of 0.21-0.49 mg/cu m, and two were exposed at concentrations less than 0.20 mg/cu m.

Lijinski and coworkers [72], Roe and associates [81], and Boutwell and Bosch [73] found an increased incidence of skin tumors in mice from creosote application. Cabot et al [71] concluded from studies in mice that creosote enhanced the skin tumorgenicity of BaP. Unfortunately, Lijinski et al and Roe et al did not characterize their creosote samples by source or composition. It is conceivable that their samples included coal tar, but it seems appropriate to conclude from the evidence available that creosote, whether or not containing tar, is a potent skin irritant, leading, on sufficient exposure, to skin tumors. Roe et al [81] also found lung tumors in creosote-exposed mice. Thus creosote, like coal tar pitch, can cause lung and skin tumors in workers.

In deriving the workplace environmental limit for coal tar products, NIOSH has considered numerous possibilities and variables. Extraction of samples with cyclohexane and calculation of the cyclohexane extractables has been found to be the optimum general method for analysis. It has been found, after experience with the particular analytical procedures currently available, that 75μg is the smallest quantity of extractables that can be reliably analyzed using the procedure described in Appendix II. If less than 75 μg of extract is obtained, the analysis cannot reliably indicate the presence of extractables in the sample of airborne coal tar products, though they may actually be present. Improvement of the analytical method and further testing may lead to future reliable analysis of less than 75 μg of cyclohexane extractables, but now this is not possible.

In considering the possible sampling regimens that could be used for coal tar products, NIOSH has reached four conclusions. First, the sampling time should be minimized to allow observation of variations of workplace environmental concentrations. This will allow a better understanding of the patterns of varying emissions from processes, and the development of better control measures. Second, personal sampling of each employee's breathing zone is the best method for sampling coal tar products the employee inhales; personal sampling pumps and cassette filter holders most easily accomplish this sampling goal. Third, the equipment used for personal sampling should be as reliable, portable, and uncumbersome as possible, but should be generally available. Fourth, the sampling volume should be as large as possible, to allow more precise measurement of the volume sampled.

In accomplishing these aims, three factors bear on the sampling regimen. First, portable personal sampling pumps that are available have useful maximum pumping rates of about 1.6 liters/minute. Second, the normal workshift is about 8 hours. Third, some time is usually necessary within a workshift to set up and maintain the sampling regimen. It is evident from these factors that, during the average 8-hour workshift, about 750 liters of air can be sampled. It has been stated that one objective of sampling for coal tar products is to keep sampling time short. However, this objective is not overriding, and NIOSH has decided that filtering a larger volume of air, ie, at least 750 liters, is a more important objective in the accurate characterization of the concentrations of airborne coal tar products in the breathing zones of employees. Therefore, NIOSH has concluded that at least 750 liters of breathing zone air must be sampled using a personal sampling device. Because the quantity of cyclohexane extractable material that can be reliably analyzed is 75 μg, it is apparent that the resulting workplace concentration limit, based on the factors noted above, viz, the lowest reliable detectable concentration of coal tar products, is 0.1 mg of cyclohexane extractables/cu m.

As explained before, the limit of detection of the analytical method is 75 μg. This method may be improved to increase its sensitivity, allowing amounts less than 75 μg to be detected reliably. If this were to occur, it is suggested that one of the objectives not realized above be reconsidered and the sampling time be decreased. With the recommended sampling and analytical method, one can analyze for coal tar products at concentrations of 0.1 mg/cu m or greater by sampling for an entire 8-hour work shift. If the concentration in the workplace air averages less than 0.1 mg/cu m for 8 hours, one can not be certain of the concentration of airborne coal tar products. In this situation, filtering more than 750 liters of air would be necessary to show that the workplace environmental concentrations of cyclohexane extractables from coal tar products are less than 0.1 mg/cu m.

(b) Sampling and Analysis

As described in Chapter IV, the optimum method for sampling uses a combination glass fiber filter and silver membrane filter in a cassette and a personal sampling pump capable of operating at 1.6 liters/minute.

Coal tar, coal tar pitches, creosote, and coal tar pitch volatiles are analyzed by determining the weight of cyclohexane-extractable material that can be extracted from the filters with the aid of ultrasonication as described in Appendix II.

(c) Medical Surveillance and Recordkeeping

It is proposed that medical surveillance be made available to employees and that it include preplacement and periodic examination of the lungs, the upper respiratory tract, and the skin. Pulmonary function tests, chest X-rays, and sputum cytology examinations should be performed to aid in detecting any developing or existing adverse effects of coal tar, coal tar pitch, and creosote on the lungs. Examination of the upper respiratory tract should be directed to the detection of possible adverse effects, including hyperplastic or premalignant changes. Preplacement and interim medical histories should supplement the information obtained from the medical tests. Periodic examinations should be given at least annually to workers frequently exposed to coal tar, coal tar pitch, and creosote to permit early detection of adverse effects on the respiratory organs and of sensitization to coal tar, coal tar pitch, and creosote. In areas of high particulate exposure, special attention should be given to the oral mucosa.

There are likely limitations on the number of sputum cytology examinations which can be accomplished by the facilities now available. Efforts should be made to increase the number of qualified laboratories available for routine analysis of cytologic specimens; these efforts should standardize procedures and increase the feasibility of performing these examinations.

Because of the slow development of carcinogenic effects of coal tar products, all medical records should be maintained for at least 30 years beyond the duration of employment.

(d) Personal Protective Equipment and Clothing

All employees assigned to areas of high exposure should wear clean long-sleeved shirts, shoe covers, head coverings, and rubber gloves. Respirators may be needed by employees working with hot coal tar pitch or with creosote. Employees working with hot coal tar pitch should wear goggles to protect the eyes.

(e) Informing Employees of Hazards

At the beginning of employment, all employees must be informed of the hazards from exposure to coal tar products. Brochures and pamphlets may be effective as aids in informing employees of hazards. In addition, signs warning of the danger of exposure to coal tar products must be posted in any work area where there is a likelihood of occupational exposure. A continuing education program, which includes training in the use of protective equipment and information about the advantages of medical examination, should be available to the employees.

(f) Work Practices

Engineering processes should be designed and operated to minimize leaks of hazardous substances, such as hot coal tar pitch, coal tar, or creosote, from pipes and valves. For operations that might increase the concentration of airborne coal tar products in the work environment, adequate ventilation must be maintained at all times. In case of an accidental leak or spill, anyone entering the area must be appropriately clothed and wear suitable respiratory protective devices. If the coal tar products contact the skin or eyes, the affected person should wash thoroughly with water and soap, flush the eyes with water, and consult a physician if necessary.

(g) Monitoring and Recordkeeping Requirements

Periodic sampling to characterize each employees' exposure is needed. This should be accomplished with due consideration of changes in environmental and process changes. Environmental and medical records need to be retained primarily to give a factual basis for the protection of the worker's health or decisions on the worker's health and rights.

VII. RESEARCH NEEDS

Proper assessment of the toxicity of coal tar products and evaluation of their potential hazard to the working population require additional research in humans and animals.

Epidemiologic Studies

Further epidemiologic studies are needed to estimate the risks of morbidity and mortality resulting from exposure to coal tar products in US workers in processes such as coal tar distillation, wood treatment with creosote, and manufacture of carbon electrodes using coal tar pitches. There is a need for more data on exposure to coal tar products in the occupational environment to determine the association between exposure and observed effects.

Animal Studies

Potential effects of long-term exposure to coal tars, pitches, and fractions of coal tar on various physiologic systems in humans and animals require investigation. Well-planned inhalation studies in several animal species are needed to determine the effects of coal tar aerosols and coal tar pitch volatiles.

Carcinogenic effects of crude coal tar products in animals and humans are well documented. To determine the carcinogenic, teratogenic, and mutagenic potential of tars, pitches, and their respective distillation fractions, detailed animal studies are needed with each type of product sampled from several sources. Techniques are needed to detect and identify the metabolites of coal tar products in the blood and urine of exposed animals and humans. These analytical techniques would be useful in characterizing exposure to coal tar products in the occupational environment.

Analytical Techniques

Existing analytical and sampling methods for determining the concentration of coal tar products in workplace air require refinement to improve the accuracy, sensitivity, and precision of the recommended methods. Investigations of other sampling and analytical techniques should also be encouraged, especially development of an analytical approach which can conveniently and routinely identify individual constituents of coal tar products at the proposed environmental limits.

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