IV. ENVIRONMENTAL DATA

Environmental Concentrations

Determinations of worker exposure to asphalt fumes have not been found in the literature. However, several papers have reported analyses of the emissions from processes that use asphalt. The benzene-soluble fraction of the particulates and the benzo(a)pyrene levels in these particulates have been reported.

A 1975 study on emissions from asphalt hot-mix plants [5] listed a range of benzene-solubles of 0.3-2.8 mg/cu m for one plant and a range of 0.2-5.4 mg/cu m for another plant. The average benzo(a)pyrene concentrations in these fractions were 11 μg/1,000 cu m and 19 μg/1,000 cu m, respectively.

Thomas and Mukai [42] reported values of 2.9, 8.3, and 9.5 g/cu m for total particulates from heated asphalt kettles, but no measurable amount of benzo(a)pyrene was detected.

In 1974, Gerstle [43] analyzed the emissions from asphalt roofing manufacturing processes. These analyses showed that the polycyclic organic matter (polar aromatic compounds) constituted between 0.0003 and 0.0019% of the total particulate emissions and that BaP accounted for approximately 10% of this polycyclic organic matter.

Sampling and Analysis

There are currently no NIOSH validated sampling and analytical methods specific for asphalt fumes. Various methods have been used to collect asphalt fumes in emission studies, including high-volume samplers using filtration [5] and impingers [42], but these studies have involved source performance standards and were not related to employee breathing-zone sampling.

Asphalt is almost completely soluble in benzene [6] and 99+% soluble in trichloroethylene [60]. Although a determination of the solubility of asphalt fumes has not been reported, it is reasonable to assume that they would have the same solubilities as the parent compounds since the fumes are not generated by excessive (cracking) temperatures. This indicates that, for the purpose of sampling and analysis, asphalt fumes are particulate polycyclic organic matter (PPOM), and that those methods developed by NIOSH and OSHA for the determination of PPOM in coal tar pitch volatiles can be used for the sampling and analysis of asphalt fumes.

More than 50 different types of instruments have been used for particulate sampling [61]. An appropriate sampler will allow the determination of either the mass concentration or the number concentration of the particles in a volume of gas. The instruments for measuring the mass concentration of a particulate can be classified into two categories according to whether or not they use preselectors, such as elutriators or preferably cyclones, to separate the coarser, nonrespirable particulates before collection. Because of the adhesive property of asphalt fumes, a preselector can induce error by trapping respirable particles. Collection without a preselector, however, can induce error by increasing the calculated mass of asphalt fumes by the amount of the total particulates that is actually in the nonrespirable size range.

Samples of PPOM have been collected on various filter media. In the 1960's, the method most often used was to draw air at a flowrate of 20-100 cu ft/min through a glass fiber filter with a high-volume sampler. A silver membrane filter for sampling coal tar pitch volatiles (or PPOM) was recommended by Richards et al [62] because it offered better weight stability than glass fiber, cellulose, or cellulose acetate filters. In a 1973 NIOSH evaluation of sampling and analysis for coke oven emissions, however, silver membrane filters were found to clog after a relatively short sampling time when emissions or moisture content was high [63]. This problem was eliminated when a glass fiber filter (without organic binder) was placed ahead of the silver filter within the sampling cassette. The combination of glass fiber and silver membrane filters, supported by a cellulose filter pad, then became the standard medium used by industrial hygienists for the collection of PPOM [64]. At present, the glass fiber filter without a silver membrane backup is considered adequate for measurement of PPOM.

After the samples are collected, the filters are extracted with an organic solvent. The most common method used for this extraction is the Soxhlet method with benzene as the solvent [64-66]. In the Soxhlet method, the filter used to collect the sample is weighed before and after exposure to the employee's environment and the difference in weight is a measure of the total particulate concentration [65]. The filter is removed from the holder and transferred to a Soxhlet apparatus, where the sample is extracted with hot benzene for 3 hours. After extraction, the filter is placed in a Millipore filtering apparatus, and the benzene extract is passed through the filters under suction to recover any particulates that were dislodged during extraction. The filter is dried and reweighed, and any loss of weight is recorded as "benzene solubles" [64-66]. This benzene-extractable fraction has been used as an index of the presence of high-molecular-weight polycyclic hydrocarbons with carcinogenic properties [65]; however, this method is actually a nonspecific measurement of the organic material in the atmosphere [67].

In a critical analysis of the "benzene-soluble" extraction method, Seim et al [64] mentioned many conditions that caused major weight-loss errors in the results, including mechanical losses during handling and discontinuous films of fine particles on the glassware that cannot be recovered by washing with benzene. Other properties able to affect the measurement of PPOM were the boiling points of individual constituents, differences in solubility, reactivity to oxidants in the presence of light, stability on adsorbents, decomposition during solvent extraction, and collection temperatures and airflow rate [68].

The Soxhlet benzene-extraction method has been modified [69] to use ultrasonic extraction in benzene of the particulate matter on the filters. This ultrasonic procedure is faster (5 minutes) and easier to perform than the Soxhlet method. After the filtrate is extracted, the benzene solution is filtered through a glass fiber filter in a microfilter holder. The total material extracted is determined by weighing the residue from an aliquot of the extract that has been evaporated to dryness and making the necessary calculation.

Various methods have been developed for identifying and quantitating the constituents of asphalt fumes [70-72], but estimation of any one constituent is of little practical value in characterizing occupational exposure because of the chemical variability of asphalts and their fumes [3-7]. Since the quantities of individual constituents of asphalt fumes are not a reliable indicator of the total concentration of fumes, NIOSH recommends that the concentration of total fumes be measured.

Total particulate concentrations should be monitored routinely by sampling with a preweighed glass-fiber filter as detailed in Appendix I [61,73]. Glass fiber filters have been selected because they will collect airborne particulates efficiently, are not hygroscopic, and do not clog as readily as membrane filters [61].

After collection of the sample, the weight of total particulates on the filter is determined by gravimetric analysis as detailed in Appendix II [61,73]. The final weight of the filter should be determined on the same balance that was used for determining the presampling weight. Before each weighing, the filter should be equilibrated in a constant humidity chamber, and a static charge neutralizer should be attached to the balance to improve the reproducibility of the weight determinations and thus enhance the gravimetric accuracy.

Because of the chemical variability of asphalt and asphalt fumes, there would be little utility or chemical consistency in attempting to estimate individual constituents of asphalt or asphalt fumes. Furthermore, there is probably an occupational hazard to laboratory personnel of undetermined magnitude associated with solvent extraction procedures involving benzene and possibly cyclohexane. A simple gravimetric method requiring no solvent extraction is therefore recommended for the estimation of occupational exposures to asphalt fumes, except for those high-dust situations in which nonextraction procedures might lead to erroneously high estimates for asphalt fumes; in such cases, the solvent extraction procedure described in Appendix III is recommended.

Engineering Controls

Where the concentration of asphalt fumes exceeds the recommended occupational exposure limit, engineering controls must be instituted to decrease the concentration of asphalt fumes to the recommended limit or below. Industrial experience indicates that local-exhaust ventilation and closed-system operations are commonly used in control of asphalt fumes during the production of asphalt and the manufacture of products containing asphalt. Such systems must be used wherever possible to control the concentration of asphalt fumes at all permanent sites where asphalt is manufactured, processed, packaged, or used. Since the major uses of asphalt, paving and roofing, are carried on outdoors in temporary locations, closed-system operations are not always feasible. In these situations, care must be exercised to ensure that environmental conditions allow an adequate dispersal of the asphalt fumes so that the air concentration in an employee's breathing zone will not exceed the recommended occupational exposure limit. Closed-systems should operate under negative pressure when possible so that, if leaks develop, the airflow will be into the system. Closed-system operations are effective only when the integrity of the system is maintained; the system should therefore be inspected frequently, and leaks should be repaired promptly.

An exhaust-ventilation system may be used if a closed system is impractical. The principles that should be applied to control workplace air concentrations of asphalt fumes have been set forth in Industrial

Ventilation--A Manual of Recommended Practices [74], published by the American Conference of Governmental Industrial Hygienists; Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2-1971 [75], published by the American National Standards Institute; and NIOSH's Recommended Industrial Ventilation Guidelines [76]. These principles and practices have been used in the asphalt industry to control the environmental emissions and possible fire hazards so that asphalt processes can comply with air pollution abatement programs [21]. Ventilation systems require regular inspection and maintenance to ensure effective operation. Therefore, a program of routine scheduled inspections, including face velocity measurements of the collecting hood, inspection of the air mover and collector, and measurements of the workplace air concentrations of asphalt fumes, should be established. Any process changes that might affect the ventilation system or the operation being ventilated must be assessed prior to implementation to ensure that the engineering controls will continue to provide adequate protection for the employees; the effectiveness of engineering controls after the process change is completed should be checked as soon as possible after the change, and not later than 3 months.

V. WORK PRACTICES

Exposure to asphalt fumes at high concentrations has been shown to adversely affect the respiratory system [15, 19,27,30] and the eyes [29]. A continuing program of instruction on the proper use of respirators, including fitting, testing, and maintenance, and a procedure for assessing the employees' abilities to wear and work with respirators, eye protective devices, and other personal protective equipment should be developed and implemented by the employer. Respiratory and eye protective devices must be maintained in good working condition and must be routinely cleaned and inspected after each use. Respiratory, eye, and other protective equipment should not be used as a substitute for effective engineering controls. Because face shields and other devices for protecting the eyes may become obscured by impacted particles of asphalt, provisions should be made to clean the front surfaces of the shields or lenses.

Skin contact with asphalt has produced thermal burns [18] and dermatitis [27] in humans, as well as dermatitis and neoplastic growths in experimental animals [3,11,17,19,31,32]. Therefore, employees working with asphalt must be provided with and required to use protective clothing and equipment to reduce the possibility of adverse affects, regardless of the air concentration of asphalt fumes in the work atmosphere.

Gloves, aprons, and other personal protective devices must be kept clean and maintained in good condition to minimize the possibility of employee injury. Cotton gloves and work clothes and safety glasses with side shields should be adequate protection for employees potentially exposed to hot asphalts.

Employees who may be exposed to hot asphalts while loading or unloading kettles or transports, or while sampling hot asphalts, should wear face shields (8-inch minimum) and heat-resistant, thermally insulated gloves. Employees working with cut-back or emulsified asphalts, which are fluid at room temperature (76 F; 25 C), should wear rubber gloves, rubber aprons, and goggles suitable for use around chemical hazards. All personal protective equipment should be cleaned frequently and respirator filter elements should be regularly inspected and replaced when necessary. Employers should ensure inspection and approval of all personal protective devices and should ensure that such equipment is stored in suitable, designated containers or locations at the job sites when they are not in use.

Work clothing should consist of a long-sleeved shirt fastened at the wrists and neck, long cuffless trousers, and heavy work shoes with nonmetallic safety toes. Clean work clothing should be put on before each work shift. At the end of the work shift, the employee should remove the soiled clothing and shower thoroughly before putting on street clothing. Soiled clothing should be drycleaned and then laundered before reuse. Handwashing and shower facilities with soap and separate lockers for work and street clothing should be provided by the employer at all permanent locations where exposure to asphalt or asphalt fumes is a possibility. At nonpermanent locations, employees should be provided with facilities for washing their hands and should be encouraged to shower after work.

Wide-mouth metal cans or pails without soldered joints should be used for sampling hot asphalt for quality control or other purposes [21].

Employees should use wire baskets or unbreakable pails to transport these samples.

A water supply for emergency first aid should be provided by a free-flowing hose at low pressure, an emergency shower, or other suitable water source. An adequate supply of a nonvolatile skin cleanser should be available. Eyewash fountains, bottles, or other suitable devices with fresh potable water, and emergency cold packs should also be available where eye or skin contact with asphalt is possible and should be inspected daily. Water in these containers should be changed daily. If eye contact with asphalt or serious skin burns should occur, the affected employee should see a physician as quickly as possible.

Smoking, drinking, eating, and dispensing or handling food should be prohibited in the immediate area of asphalt use or where asphalt fumes are present. The employer should designate at least one specific area for the activities listed above. Employees should be instructed to wash their hands before eating, drinking, or smoking, and before using toilet facilities.

All new or newly assigned asphalt workers should receive on-the-job training before they are allowed to work independently. Employers should determine that all employees are thoroughly familiar with all prescribed work practices before they are allowed to work alone. Employers should ensure that employees understand the instructions given to them. Periodic safety and health meetings should be conducted by the employer at least annually, and records of attendance should be maintained.

The duties of employees involved in maintenance and repair activities pose special problems of potential contact and exposure, especially during work in enclosed systems or in operations involving ventilation system repair and maintenance. Written and oral instructions for recurring maintenance procedures, such as tank cleaning, production line changes, and repair or replacement of valves or conduits, should be provided to the appropriate personnel before they begin these or similar procedures.

Spills of hot asphalt may be dusted with washed sand or other nonhazardous mineral aggregates, such as vermiculite. Spills of asphalts that are fluid at room temperature should be dusted with a suitable oil absorbent. When the material can be handled safely, it should be removed from the work area and may be disposed of in a sanitary landfill according to local, state, and federal regulations. All permanent asphalt storage facilities should be appropriately diked to contain emergency spills.

Asphalt fumes can explode when they are concentrated in an enclosed environment and supplied with an ignition source [21]. Ventilation procedures should therefore be used where possible to minimize the concentration of fumes regardless of possible employee exposure, and possible ignition sources should be eliminated from areas in which fumes are likely to be concentrated. Areas and containers in which an explosive accumulation of asphalt fumes is possible should be posted and labeled with appropriate warnings of the explosive hazard.

The cut-back asphalts present the greatest fire and explosion hazard because of the volatile solvents used in their formulation. Because of their low flashpoints, they require extreme caution, and, whenever feasible, based on job requirements, they should always be handled and stored at temperatures below the flashpoint, not to exceed 212 F (100 C) [21]. Cut-back asphalts should not be heated or stored above the flashpoint temperature. Because of the high heat retention of asphalts, contact with water or light hydrocarbons should be avoided to minimize the froth-over or boil-over hazards.

Written and oral instructions detailing proper handling procedures and work practices for loading and transporting bulk asphalt should be provided to each individual engaged in these activities by the producer or storage facility supplying the asphalt. Moreover, the employer should ensure that these individuals follow good work practices while loading, unloading, or transporting asphalt on his premises.

Entry into asphalt work areas associated with permanent facilities should be restricted to employees and guests accompanied by representatives of the employer [21]. The employer should be responsible for providing all guests with appropriate safety equipment and ensuring that it is used. A controlled-access system should be developed and used for all guests visiting the work areas.

When asphalt is used in the open, as in paving and roofing operations, employees should station themselves on the windward side of any source of asphalt emissions, as far as is possible. Sources of ignition, eg, smoking or open flames, should not be allowed within 15 meters (50 feet) of asphalt kettles, pavers, or, especially, spray rigs dispensing cut-back asphalt. Engines or burners on kettles should not be refueled while they are operating. No flammable liquid with a flashpoint of less than 38 C (100 F) should be used for any purpose within 15 meters (50 feet) of an operating asphalt kettle or any other source of ignition. All hoses and fittings should be checked daily for wear leading to leakage and should be repaired if leaks are discovered.

VI. DEVELOPMENT OF STANDARD

Basis for Previous Standards

The earliest workplace environmental limit for asphalt fumes was published in 1971 by the American Conference of Governmental Industrial Hygienists (ACGIH) [77], which recommended a threshold limit value (TLV)of 5 mg/cu m for asphalt fumes as a Time Weighted Average (TWA) concentration for an 8-hour workday in a 40-hour workweek. In the 1971 Documentation of the Threshold Limit Values for Substances in Workroom Air [78], this TLV was justified by the animal inhalation experiments of Hueper and Payne [19] and the health survey of petroleum asphalt workers conducted by Baylor and Weaver [27]. Supporting opinions were presented by the industrial hygienists who conducted the survey of working conditions for inclusion in the Documentation. They said that "...working conditions were satisfactory when asphalt fume levels were kept below 10 mg/cu m....Accordingly, a TLV of 5 mg/cu m is recommended to maintain good housekeeping conditions and reduce the risk of possible carcinogenicity [78]." In 1976, the ACGIH [79] proposed a tentative short-term exposure limit (STEL) of 10 mg/cu m for a 15-minute exposure to asphalt fumes. No change in the TLV was recommended in 1976 [79] or in the discussion of the basis for the TLV in the most recent (1974) Documentation [80].

In 1972, the Federal Register (37:24749, November 21, 1972) contained an interpretative rule of the term "coal tar pitch volatiles": "...coal tar pitch volatiles include the fused polycyclic hydrocarbons which volatilize from the distillation residues of coal, petroleum, wood, and other organic matter." This has been reprinted as 29 CFR 1910.1002. The general philosophy behind this interpretation was that "all of these volatiles have the same basic composition and...present the same dangers to a person's health." The interpretation has been reinforced more recently in the Federal Register (41:46752, October 22, 1976) by the statement: "The existing standard will continue to apply to employee exposures to coal tar pitch volatiles outside of coke plants, such as the petroleum asphalt industry, including those parts of the steel plant other than the regulated area."

In 1973, objection to the original interpretative ruling was made by the American Petroleum Institute (API), on the basis that petroleum asphalt, unlike coal tar and coal tar pitch, is not a product of destructive (high-temperature) distillation and does not contain the comparatively high concentration of polycyclic compounds that is common in coal tar and coal tar pitch. The API proposed that the rule be amended by insertion of "destructive" before "distillation." This proposal was repeated by the Asphalt Institute in August of 1975. In September of 1975, the Division of Occupational and Radiological Health of the Tennessee Department of Public Health stated that it had found high concentrations of benzene-soluble materials in the carbon products industry, in which materials other than coal tar pitch that contain benzene-soluble volatiles are used. That department expressed the opinion that the coal tar pitch volatiles standard as stated was inapplicable to that industry and asked that an enforceable standard more specific for coal tar pitch volatiles be promulgated.

In October of 1975, a roofing manufacturer in New Jersey was cited by OSHA for allowing exposure of one of its employees to "coal tar pitch volatiles associated with petroleum distillation residues" at a concentration in excess of the TWA concentration allowed in 29 CFR 1910.1000(a). This citation was vacated by a settlement agreement in January of 1977, the basis of the settlement being that exposures to benzene-soluble volatiles derived from petroleum asphalt at concentrations of up to 2.5 mg/cu m would be acceptable (personal communication, C. Lorr to E. Baier, August 1977). In essence, therefore, there appears to be a "standard" for exposure to volatiles from asphalt at 2.5 mg/cu m despite the interpretative rule of 29 CFR 1910.1002.

No standards for occupational exposure to asphalt fumes established by foreign countries have been found.

Basis for the Recommended Standard

(a) Permissible Exposure Limits

The literature on the biologic effects of exposure to asphalt fumes is often confusing and contradictory. Some of the problems arise from failure to distinguish between asphalt (residue from fractional distillation of petroleum) and tar (product from destructive distillation of petroleum, coal, peat, lignite, wood, or other organic substances) or pitch (residue from fractional distillation of tars). However, the toxicity of asphalt [3,17,19] and asphalt fumes [18,20] is substantially lower than that of coal tar, coal tar pitch, and their fumes. For futher information on the toxicities of coal tar and coal tar pitch and their fumes, see NIOSH's Criteria for a Recommended Standard for Occupational Exposure to Coal Tar and Coal Tar Pitch. Because of this difference in toxicity, which has been documented in studies where both materials were tested, care must be exercised in determining and defining exposure to asphalt fumes. Therefore, this recommended standard for asphalt fumes is based solely on their reported toxicity and not on their resemblance to fumes from tars and pitches.

Tumorigenic reactions have been observed in experimental animals after dermal application of undiluted asphalt [19,32] or asphalt mixed with solvents [3,17,19,31,32]. The incidence of these tumorigenic reactions, including both malignant and nonmalignant tumors, varies from zero to 9.5% for the hot asphalt and zero to 17.6% for the asphalt in a solvent. The mean incidence of tumor formation as calculated for the total number of animals beginning each experiment was 4.73% for the hot asphalt, 4.96% for the asphalt mixed with a solvent, and 4.69% for three control groups. Because of the lack of quantitative dose-response data for tumorigenic responses in these experiments, it is not possible to determine a safe limit for exposure to asphalt. The evidence from experiments with animals [19,32] indicates, however, that intimate contact must be maintained between the asphalt and the skin for a relatively long time before any neoplastic potential becomes manifest. The available data do not indicate a significant risk of carcinogenesis in human populations occupationally exposed to asphalt or asphalt fumes [27]. The usual personal hygiene of employees and the discontinuous nature of occupational exposure to asphalt and its fumes make a significant risk of carcinogenesis among such employees unlikely. In fact, only two human cases of carcinomas have been attributed to exposure to asphalt [16,24], but in one case [16] the presenters stated that asphalt may not have been the causative agent.

A health hazard survey [27] of 462 petroleum asphalt workers found no significant differences between the number and severity of current health problems in these workers and those in a control population of 379 refinery workers. In the past medical histories, however, the frequency of lung disease other than cancer in the asphalt workers was noted to be 1.96 times that in the control population (significant at $P<0.05$, Chi Square). Whether these histories pertained to health problems prior to work with asphalt was not reported. Comparison of the frequency of lung disease in asphalt workers with data on lung disease in the general working population [28] showed no significant difference between the groups in past or present illness. Roofing workers reported suffering no adverse health effects when working with asphalt [18,20]. Four trucking companies with a total of more than 5,000 drivers exposed to asphalt fumes and dust reported no known cases of lung or skin disease attributable to asphalt, and three large roofing companies employing over 1,100 asphalt workers found no evidence of ill health related to asphalt exposure [27]. Thirty-one construction or paving companies reported one case of ill health attributed to asphalt in 11,478 man-years of work experience, and 15 state boards of health replying to a questionnaire mentioned only one case of nasal irritation and 14 cases of dermatitis attributed to asphalt or asphalt fumes among the cases of injury and ill health known to them [27]. Most of these data were obtained by questionnaire or by corroborative examinations of workers and were not accompanied by information relating to duration or concentration of exposures.

There also have been reports of respiratory effects in humans [15] and in animals [19,30] exposed to asphalt fumes. Quantitative determinations of the concentrations of the fumes were not presented, but subjective descriptions of the environments as acrid and irritating to the nose and throat [15] or as containing dense oily fumes [30] indicated that concentrations were relatively high. Observed effects in humans have included burning sensations in the nose, throat, and chest, nasal mucous discharge, coughing, and expectoration, tonsillitis, pharyngitis, and loss of voice, bronchitis and increased vascularization of the bronchi, and emphysema and harsh respirations with rales [15]. It should be recalled, however, that the causative agent was not definitely identified as asphalt fumes. The following effects have been observed in animals after exposure to asphalt fumes at estimated concentrations of 40-2,000 mg/cu m for 2 years: pneumonitis with peribronchial adenomatosis, squamous cell metaplasia of the bronchial mucosa, bronchiectatic lumina, and emphysema [19,30].

In animal studies, pulmonary lesions were scattered [19,30]. The effects on both the upper and lower respiratory tracts were transient in humans exposed for less than 1 year [15]. The respiratory effects observed in animals after exposure to asphalt fumes were similar to those observed after inhalation exposure to nonspecific respiratory irritants at high concentrations, some animals being relatively refractory to the irritant. None of the reports in the literature demonstrates conclusively that asphalt fumes have a carcinogenic potential in humans or animals. Since so few cases of irritation in humans have been attributed to asphalt fumes even though the industrial experience with asphalt includes large numbers of workers over several decades, the occupational health hazard from these fumes appears to be minimal.

Adverse skin effects other than tumorigenesis from exposure to asphalt have also been observed in humans [18,27] and in animals [3,17,19,31,32]. The investigators have rarely reported dose or exposure concentrations, so that quantitative determination of a dose-response relationship is not possible. The adverse reactions reported in humans included occasional burns from hot asphalt [18] and 14 cases of dermatitis recorded by a state board of health [27] and attributed to exposure to asphalt. Adverse nontumorigenic skin effects reported in animals were similar to those that result from application of benzene or toluene, which were used as solvents for the asphalt. These effects included hair loss, chronic dermatitis, and dryness and scaling of the skin at the application site [3,17,19,31,32]. Asphalt fumes directed into the eyes of immobilized rabbits caused mild conjunctivitis and slight infiltration of the cornea, but both conditions disappeared after the exposure was discontinued [29].

The risk to the health of employees exposed to asphalt fumes is the result of the potential irritating actions of the fumes on the eyes and adjacent tissues and on the respiratory tract, and of the asphalt from which the fumes are generated on the skin or other tissues of contact. Although there have been few reports attributing adverse effects to occupational exposure to asphalt and asphalt fumes, animal data indicate a risk from exposure to these substances at high concentrations.

The particle sizes of asphalt fumes have been reported to be less than 5 μm [5], ie, in the respirable range. The data indicate that the effects of exposure to asphalt fumes at high concentrations are qualitatively and quantitatively similar to those of exposure to any nonspecific respiratory irritant, and while no experiment has clearly demonstrated a direct carcinogenic hazard associated with asphalt fumes, NIOSH is concerned that future scientific investigations may indicate a greater occupational hazard from asphalt fumes than is currently documented in the literature. Concern for employee health requires that the possibility of short-term and long-term effects of asphalt and asphalt fumes be minimized. This concern has been precipitated by the paucity of credible toxicologic evidence and the confusion in the literature regarding asphalts, tars, and pitches. Inadequate scientific research in these particular areas has left unresolved issues, and these compel NIOSH to recommend a ceiling concentration limit of 5 mg/cu m based on total particulate. Limiting employee exposure to asphalt fumes to a concentration of not more than 5 mg/cu m should protect against possible respiratory or eye irritation over the entire normal working life of the individual and minimize the likelihood of a neoplastic response from exposure to asphalt fumes.

(b) Sampling and Analysis

Technology is currently available to sample and analyze asphalt fumes at the recommended occupational exposure limits and to provide necessary engineering controls. Sampling and analysis should be carried out by the recommended sampling and analytical methods for asphalt fumes as discussed in Chapter IV and presented in greater detail in Appendices I, II, and III. These methods provide for sampling of the workers' breathing zones by means of personal sampling pumps and glass fiber filters and for gravimetric determinations of particulates collected on the filters. Because of the physical properties of the particles of asphalt fumes, their deformability and adhesiveness, it is not practical to use a separation technique based on particle size for separation of respirable from nonrespirable particulates when collecting breathing zone samples of asphalt fumes.

(c) Medical Surveillance and Recordkeeping

Respiratory irritation has been found in humans [15,27], and respiratory and eye irritation have been reported in animals [19,29,30] after exposure to asphalt fumes. Skin irritation and burns resulting from contact with hot asphalt have been reported in humans [18,27] and skin irritation and neoplastic reactions, both nonmalignant and malignant, have been produced in asphalt-exposed animals [3,17,19,31,32]. Although these reports are few and often contradictory, they do suggest a potential hazard from exposure to asphalt and asphalt fumes. A medical surveillance program should therefore be established to provide for the timely detection of any adverse health effects and should include preplacement and periodic medical examinations that give attention to the eyes, skin, respiratory system, respiratory function tests, and chest roentgenograms. Personnel potentially exposed to asphalt or asphalt fumes must be warned and advised of the possible adverse effects of exposure and must be informed of the signs and symptoms of the possible disorders. If eye contact with hot, cut-back, or emulsified asphalt occurs, the affected areas should be immediately flushed with water, and the employee should be examined by a physician. If substantial skin contact with hot asphalt occurs, the area should be immersed in cold water, dressed with an emergency cold pack, or packed with ice, and the employee should be examined by a physician as quickly as possible.

Because asphalt has the potential to produce skin neoplasms in experimental animals [11,31,32], all medical records should be kept for 30 years after termination of employment. This will allow time for future detection of delayed effects that may be related to the employee's known occupational exposure.

(d) Personal Protective Equipment and Clothing

Respiratory irritation has been reported in humans [15] and animals [19,30] exposed to high concentrations of asphalt fumes. Respirators should be available therefore and worn where concentrations of asphalt fumes exceed the recommended occupational exposure limit. The use of respirators should not be considered to be a substitute for proper engineering and administrative controls. Dermal and eye contact with liquid asphalt or asphalt fumes may induce irritation in humans [27] and in animals [3,17,19,29,31,32]. Care must therefore be exercised to ensure adequate protection against contact regardless of the air concentration of asphalt fumes. Personal protective equipment and clothing, including eye protective devices and gloves, should be available and should be worn where exposure to liquid asphalt is likely. Work practices that prevent skin and eye contact should be followed. A source of clean water and emergency cold packs should be available for immediate use if accidental contact occurs. Ice packs are useful if the skin comes into contact with molten asphalt.

(e) Informing Employees of Hazards

A continuing education program is an important part of a preventive hygiene program for employees occupationally exposed to such potentially hazardous materials as asphalt or asphalt fumes. Properly trained persons should periodically (at least annually) apprise employees of the possible sources of exposure to asphalt or asphalt fumes, the adverse effects associated with such exposures, the engineering controls and work practices in use and being planned to limit such exposures, the first-aid measures to be taken upon accidental exposure, and the procedures used to monitor environmental controls and the health status of employees.

(f) Work Practices

Engineering controls must be used to maintain concentrations of asphalt fumes within the recommended environmental limits. During the time required to install adequate controls and equipment, to make process changes, to perform routine maintenance operations, or to make emergency repairs, exposure to asphalt fumes may be minimized by the use of respirators. However, respirators should not be used as a substitute for proper engineering controls in normal operations.

In the interest of good personal hygiene and work practices, it is recommended that food storage, handling, dispensing, and eating be prohibited in asphalt work areas, regardless of the concentrations of asphalt fumes. In addition, it is recommended that employees who work in an asphalt work area wash their hands thoroughly before eating, smoking, or using toilet facilities.

(g) Monitoring and Recordkeeping

Many employees come in contact with only small amounts or low concentrations of asphalt or asphalt fumes, usually only in the case of an accident, during maintenance procedures, or in open-air environments. Therefore, under normal working conditions, it should not be necessary to conduct extensive monitoring and surveillance procedures for employees with negligible contact. Where exposure to asphalt fumes at concentrations above one-half the recommended occupational exposure limit or to hot, cut-back, or emulsified asphalt can occur, adequate protection against the potential irritating effects of asphalt and asphalt fumes must be ensured. Concern for employee health requires that protective measures be instituted at concentrations at or below the recommended workplace exposure limit to ensure that exposures stay below that limit. For this reason, an industrial hygiene survey should be conducted every 3 years in those occupational environments in which concentrations of asphalt fumes are at or below one-half the recommended occupational exposure limit. When concentrations are above one-half the recommended occupational exposure limit, annual personal monitoring is required. Records of monitoring and process changes should be retained for 30 years. This is in accord with the provisions of the Toxic Substances Control Act and will allow an analysis of the efficiency of engineering controls, of exposure potentials, and of the impact of process changes on the concentrations of the fumes and on potential exposure of employees.