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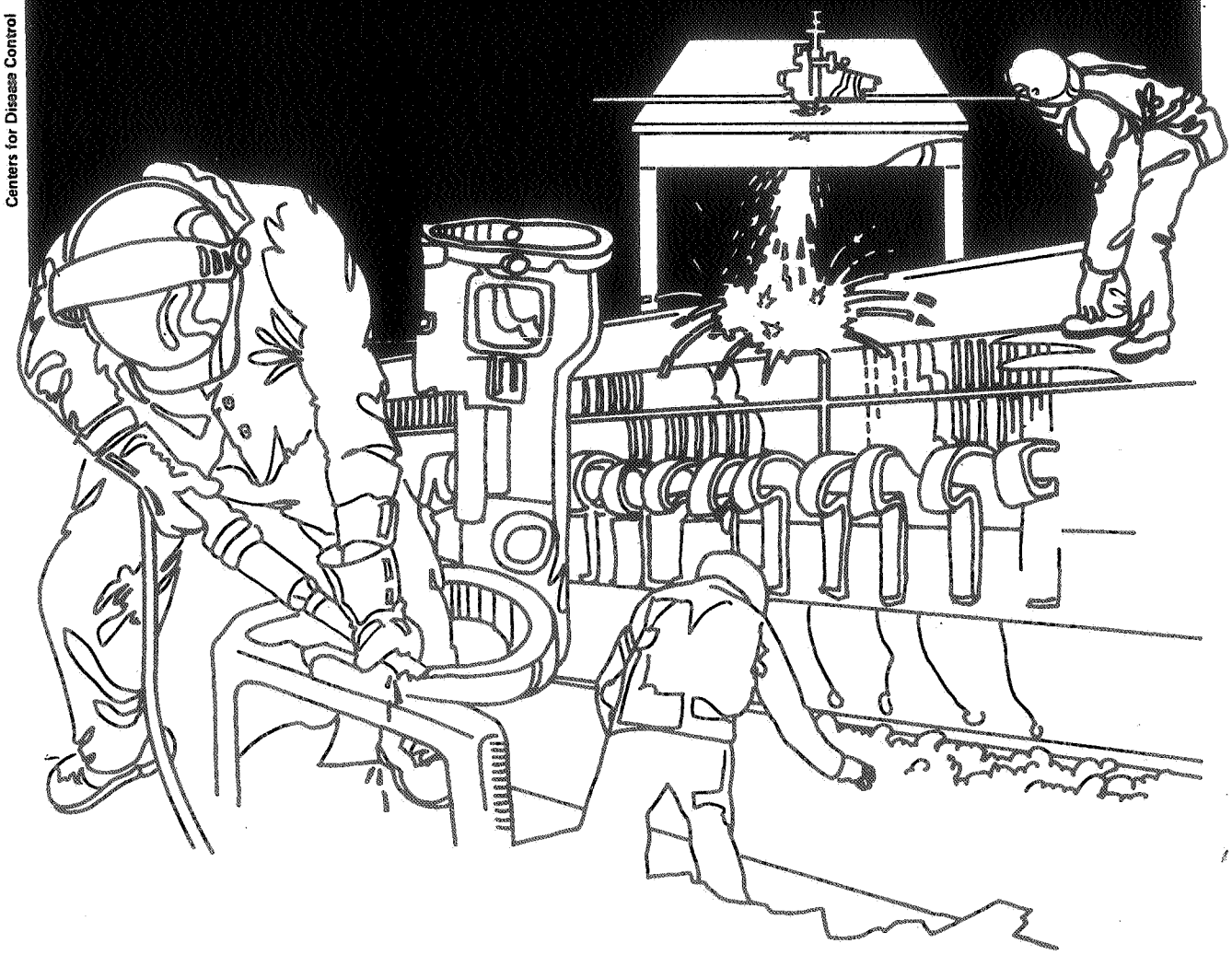

Health Hazard Evaluation Report

HETA 83-210-1887
ROOFING CONSTRUCTION
HOUSTON, TEXAS

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 83-210-1887
APRIL 1988
ROOFING CONSTRUCTION
HOUSTON, TEXAS

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I. SUMMARY

In March 1983 the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Union of Roofers, Waterproofers, and Allied Workers to evaluate employee exposures to various chemicals during roofing activities. The request was for evaluations of build-up and single-ply roofing systems.

NIOSH investigators conducted environmental and medical evaluations on April 11-14, 1983. Three roofing systems were evaluated: 1) tear-off and application of a coal-tar pitch roofing system, 2) tear-off and application of a petroleum asphalt roofing system, and 3) application of a single-ply modified asphalt roofing system (Koppers). The environmental evaluation consisted of collecting air samples for the contaminants anticipated from each roofing operation. For the hot, build-up roofs (petroleum asphalt and coal tar pitch) this included total particulates, benzene solubles, and polynuclear aromatic hydrocarbons (PNAs). For the Koppers roofing system, perchloroethylene and hydrogen chloride (HCl) gas were evaluated in addition to PNAs.

Airborne concentrations of total PNAs ranged from non-detectable (ND) to 48 ug/m^3 for 5 samples collected at the Koppers roofing site. Total PNAs for the 24 air samples collected at the petroleum asphalt roofing site ranged from ND to 110 ug/m^3. Twenty-four air samples collected at the coal tar pitch roofing site ranged from ND to 388 ug/m^3 for total PNAs. The highest concentrations for an individual PNA at each site were 48 ug/m^3 for benzo(c)phenanthrene at the Koppers site, 54.9 ug/m^3 for phenanthene at the petroleum asphalt site, and 91.6 ug/m^3 for acenaphthene at the pitch site. The benzene soluble fraction ranged from ND to 2970 ug/m^3 at the pitch site, from ND to 1440 ug/m^3 at the asphalt site, and from ND to 1890 at the Koppers site. Total particulates ranged from less than 30 to 16030 ug/m^3 at the pitch site, and from less than 25 to 1040 ug/m^3 at the asphalt site.

These data indicate that personal exposures were highest at the coal tar pitch site. Twenty percent (1 of 5) of the Koppers personal air samples, 42% (10 of 24) of the petroleum asphalt samples and 85% (22 of 24) of the coal-tar pitch samples had detectable concentrations of PNAs. Spraying the roof with water, as was done during day 2 at the pitch site, appeared to effectively reduce exposures. Arithmetic mean values for total PNAs and total particulate samples at the coal tar pitch site were 13.1 and 853 ug/m^3 when the roof was wetted and 63 and 3530 ug/m^3, respectively when the roof was not wetted.

At the Koppers site, air concentrations of perchloroethylene on three personal samples ranged from ND to 2.39 mg/m^3, and HCl was not detected on any or the three air samples collected.

The medical evaluation consisted of administration of a questionnaire addressing the use of personal protective equipment, current symptoms and symptoms during the previous month. A limited physical examination of the eyes and exposed skin was also performed.

Symptoms reported during the previous month for the hot, build-up roofs included eye irritation and skin irritation, both of which were attributed to coal tar pitch (CTP) rather than petroleum asphalt. Symptoms for the single-ply system were nasal irritation and shortness of breath. Symptoms on the days of the survey included burning, tingling and itching of the skin; and burning and tearing of the eyes.

Signs on physical examinations included irritations of the eye including gross conjunctivitis and photophobia; aging of skin and livido "network" marking; degeneration of the cartilage of the ear; meilomian gland cysts; squamous acanthomas, keratin cysts, fibreopithelial polyps, and burns. Signs not attributed to pitch or asphalt included eye loss, acute trauma, and calluses.

Based on these results the NIOSH investigators have concluded that employees were exposed to potentially hazardous concentrations of coal tar products including PNAs at the coal tar pitch and petroleum asphalt roofing sites. Personal exposure concentrations were higher at the CTP site. Spraying water on the old roof prior to tear-off resulted in lower personal airborne concentrations. Recommendations aimed at reducing exposures are included in Section VIII.

KEYWORDS: SIC 3444 (Roofing and Sheet Metal Work). Coal tar pitch, petroleum asphalt, Koppers, hot-build up roofing, single-ply roofing, health effects, eye irritation, skin irritation, nasal irritation, conjunctivitis, photophobia, aging of the skin, PNAs, polynuclear aromatic hydrocarbons, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(c)phenanthrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene.

II. INTRODUCTION

On March 25, 1983, the National Institute for Occupational Safety and Health received a request from an authorized representative of the Union of United Roofers, Waterproofers, and Allied Workers to assess exposures to various chemicals among employees involved in roofing activities.

A team of NIOSH investigators conducted an environmental and medical evaluation at three roofing sites located in the Houston, Texas area. The three roofing sites included: 1) tear off and application of an petroleum asphalt roofing system, 2) tear off and application of a coal tar pitch (CTP) roofing system, and, 3) application of a single-ply modified asphalt roofing system (Koppers). All three roofing sites were evaluated for exposure to PNAs and benzene solubles and, for the Koppers system, exposure to hydrogen chloride gas and organic vapors. In addition, each worker on whom air samples were taken had a limited medical evaluation.

III. BACKGROUND

Roofing systems have evolved over the years from the original hot build-up systems of petroleum asphalt and coal tar pitch to single-ply systems using a multitude of materials and solvents. The older hot systems involve multiple layers of insulation and pitch or asphalt, with many roofs incorporating 5 or 6 layers of material. Where a roof is being replaced, the old roof is removed in a operation called tear-off. Single-ply systems generally include the application of a layer of insulation and a membrane layer on top of the insulation. A ballast material such as "gravel" is often applied on top of the membrane. Several types of single-ply roofs have been developed, each using a different type of membrane such as: modified bitumen, modified asphalt (Koppers), rubber, and polyvinyl chloride. Individual sheets of the membranes are glued or melted together to form a continuous sheet.

Installation of both the CTP and asphalt systems evaluated during this study involved initial removal of the old roof using hand and power tools. Wheelbarrows were used to haul the waste material to a spot where the material was dumped into a refuse container. Meanwhile, solid plugs of CTP, which are normally transferred to the roofing site in 55-gallon drums, were broken up and melted in a heated container. The semi-liquid material was then transferred into application vessels. The slurry and insulation were applied in layers to the desired depth.

Roofing crews usually vary in size from about 5 to 15. Job classifications include (in decreasing order of seniority): foreman, journeyman, journeyman helper, apprentice helper and helper. The roofer starts out as a helper for a variable period (eight months to six years in this study). Tasks performed during tear-off include tearing off and picking up loose pieces of old roof, and dumping wheelbarrows full of tear-off material over the edge of the building. Tasks performed during application include transporting "hot" material and laying insulation. The skilled workmen, such as journeyman, may run the power tools (cutter, broom, vacuum) during tear-off and may mopp, roll paper, or act as kettleman during application. The journeyman helper and apprentice are intermediate in seniority and do a combination of these activities. However, in practice, all roofers may switch around and perform various tasks during the day. Both tear-off (usually in the morning) and application (in the afternoon) can be done by the same crew on the same day.

The Koppers system, which was being applied to a new building, involved laying down a layer of insulation and covering it with sheets of modified asphalt with an aluminum liner. The edge of the asphalt sheets were melted together using a hand-held propane torch.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Personal breathing zone air samples for total particulate, benzene solubles, and PNAs were collected on preweighed Teflon filters at a flowrate of 2 liters per minute (lpm) during tear-off operations. All filters were first analyzed gravemetrically. Samples were then analyzed for benzene solubles and 17 specific PNAs following NIOSH Technical Bulletin TB-001 - with modifications. Multiple bulk samples of dust from the petroleum asphalt and coal tar pitch roofing sites were collected. The bulk samples were desorbed with different solvents (benzene, acetonitrile and cyclohexane) to determine the most appropriate solvent for filter analyses. Based on laboratory analysis of bulk samples, benzene was selected as the solvent of choice for field samples. The PNA analyses included the following compounds: acenaphthylene (ACL), acenaphthene (ACE), fluorene (FLU), phenanthrene (PHE), anthracene (ANT), fluoranthene (FLE), pyrene (PYR), benzo(c)phenanthrene (BCP), benzo(a)anthracene (BAA), chrysene (CHY), benzo(e)pyrene (BEP), benzo(b)fluoranthene (BBF), benzo(k)fluoranthene (BKF), benzo(a)pyrene (BAP), dibenz(a,h)anthracene (DAH), benzo(g,h,i)perylene (BGP) and indeno(1,2,3-cd)pyrene (INP). The limit of detection ranged from 0.25 to 0.5 micrograms of each PNA per filter.

Personal breathing zone air samples for determinations of benzene solubles and PNAs during application of the petroleum asphalt, coal tar pitch and Koppers, were collected using Teflon filters in series with XAD-2 tubes at a flowrate of 2 liters per minutes. At the Koppers site air samples were also collected for perchloroethylene and HCl on sorbent tubes attached via flexible tubing to battery operated pumps calibrated at a known flow rate.

Whenever possible published NIOSH sampling and analytical methods were used.[1] Table 1 provides additional information on the sampling and analytical methods.

B. Medical

All 13 roofers were evaluated at the coal tar pitch operation (site 1) and all 14 at the petroleum asphalt operation (site 2). Job classifications at site 1, were foreman/journeyman (6), apprentice (5), and helper (2); at site 2, they were foreman/journeyman (2), journeyman helper (5), and helper (7). The evaluation included (a) a questionnaire to elicit symptoms reported over the past month, symptoms reported on the day of evaluation (coincident with personal breathing zone air sampling), use of personal protective equipment, factors that might aggravate health effects; and (b) a limited physical examination of the eyes and exposed skin. Observed lesions were photographed and the slides were reviewed with a dermatologist at the University of Cincinnati. Workers at site 1 were interviewed again on day 2. Five roofers at site 3 (Koppers or single-ply) were interviewed regarding symptoms reported during the previous month. No comparison group was available at the roofing sites, but, four non-roofing workers (two sheet metal workers at site 1 and two cement workers at site 2) were interviewed regarding symptoms experienced during the past month.

V. EVALUATION CRITERIA

A. General Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage

may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH recommended exposure limits (REL) 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) Occupational Health Standards.[2-6] Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbons (PNAs) are the constituents of concern in petroleum asphalt and coal tar pitch products. These large molecules (Figure 1) contain numerous 6 carbon rings and have been shown to be carcinogenic as a group with certain individual PNAs exhibiting increased carcinogenic capability. There are

potentially thousands of different PNAs in pitch. PNAs can be separated out of particulate samples using solvents like benzene or cyclohexane. By limiting exposure to the soluble materials of pitch, the cancer risk is believed to be reduced.[7-9]

Older hot roofing systems used either coal tar pitch or petroleum asphalt materials. (Petroleum asphalt is the residue from the fractional distillation of petroleum products.) Generally, coal tar pitch is believed to be more toxic than petroleum asphalt due to higher quantities of soluble PNAs.

Several PNAs including benzo(a)pyrene and benzanthracene have been shown to be carcinogenic in animals. From the epidemiologic and experimental toxicologic evidence on coal tar products, NIOSH has concluded that these are carcinogens and can increase the risk for lung cancer and skin neoplasms (benign and malignant).[7] An epidemiologic mortality study of members of the United Slate, Tile and Composition Roofers, Damp and Waterproof Worker's Association found elevated death rates from lung cancer and cancer of several other sites.[10] These roofers had worked with both CTP and petroleum asphalt. This study found an elevated standardized mortality ratio for skin cancer (excluding melanoma) of 4.00.

Investigators have documented carcinogenic activity in laboratory animals exposed to either petroleum asphalt or coal tar pitch fumes.[11] NIOSH investigators also found carcinogenic activity for both petroleum asphalt and coal tar pitch fumes and that carcinogenic activity increased when the pitch roofing materials were heated to 316°C as opposed to heating the materials to 232°C.[12]

Excess risks of lung cancer, oral cancer, and skin neoplasms (benign and malignant) have been found in working populations handling coal-tar products, which NIOSH has defined to include coal-tar, coal-tar pitch, and creosote.[7,8]

The acute toxic effects of exposure to coal-tar pitch include skin and mucous membrane irritation mediated directly and, more noticeably, through photosensitivity reactions. These reactions involve an interaction between the photosensitizing agent (PNAs) and ultraviolet (UV) radiation, a component of sunlight. The mechanism involves the absorption of this radiant energy by the skin and by the PNAs on the skin, which can then result in cell damage.[9] As expected, these reactions affect outdoor workers who handle these materials and receive exposure to sunlight. Thus, these reactions are more frequent and severe in the summer and during mid-day.

A TWA exposure of 0.2 ug/m^3 was recommended by the coke oven advisory committee for benzo(a)pyrene under the OSHA 29 CFR 1910.1029 coke oven emissions standards, but was not adopted. A special NIOSH hazard review of chrysene recommended that it be controlled as an occupational carcinogen.[13] Also, ACGIH includes chrysene and benzo(a)pyrene in its list of industrial substances suspected of carcinogenic potential for people (A2 carcinogen).[4,5]

For petroleum asphalt fumes, both NIOSH and ACGIH currently have exposure criteria of 5 mg/m^3.[4,5,8] OSHA currently has no exposure criteria.[6] Current occupational exposure criteria for coal tar products are 0.1 mg/m^3 for NIOSH (cyclohexane solubles) and 0.2 mg/m^3 for OSHA and ACGIH (benzene solubles).[4-7] NIOSH has since modified the analytical technique for PNAs so that several solvents are tested using bulk dust or air samples, and the solvent that extracts the greater guantity of PNAs is used for the solvent extractable portion of the field samples.[1]

VI. RESULTS

A. Environmental

Tables 2-7 present the results of each personal breathing zone sample by site and Table 8 summarizes these results by the type of roof evaluated. A total of 53 personal breathing zone samples were collected, 24 at the coal tar pitch site, 24 at the petroleum asphalt site, and 5 at the Koppers site.

Benzene solubles ranged from ND to 2970 ug/m^3 at the coal tar pitch site, from ND to 1440 ug/m^3 at the petroleum asphalt site, and from ND to 1890 ug/m^3 at the Koppers site. Total particulates ranged from less than 30 to 16030 ug/m^3 (16 samples) at the coal tar pitch site, and from less than 25 to 1040 ug/m^3 (18 samples) at the petroleum asphalt site.

The highest PNA concentrations were obtained at the pitch site; 22 of 24 (85%) samples had detectable levels of PNAs. Total PNA air concentrations ranged from non-detectable (ND) to 388 ug/m^3.

For the asphalt site, 10 of 24 (42%) samples had detectable PNA concentrations. Total PNAs ranged from ND to 110 ug/m^3. For the Koppers site only 1 of 5 (20%) samples had detectable levels of PNAs. Benzo(c)phenanthrene was detected at a concentration of 48 ug/m^3.

For individual PNAs at the other two sites, 16 of the 17 PNAs included in the laboratory analysis were detected, on at least one sample. Air concentrations for specific PNAs ranged up to 91.6 ug/m^3 for acenaphthene. Fluoranthene was detected most often (6 of 24 samples for the asphalt site and 19 of 26 for the pitch site) at air concentration of up to 47.3 ug/m^3.

Personal exposures for total PNAs and total particulates were both lower on day 2 at the coal tar pitch site. The roof was wetted on day 2 but not wetted on day 1. The arithmetic mean values for all PNA personal breathing zone samples, except those from the kettleman were 63 ug/m^3 (13 samples) on day 1 (4/11/83) and 13.1 ug/m^3 (9 samples) on the day 2 (4/12/83). Using a paired data statistical comparison the mean of the PNA exposures for the wet day (13.1 ug/m^3) was significantly ($p<.01$) less than the mean for the dry day (63 ug/m^3). Arithmetic means for total particulates were 853 ug/m^3 for 9 samples on day 2 (roof was wetted) and 3530 for 7 samples on day 1 (roof was dry).

Table 9 presents the results of three personal breathing zone air samples collected for perchloroethylene at the Koppers site. Two had detectable concentrations, 2.07 and to 2.39 mg/m^3. These values are below the OSHA and ACGIH criteria of 770 and 335 mg/m^3, respectively.[4-6] NIOSH, however, considers perchloroethylene to be a potential carcinogen and recommends that workplace exposure levels be minimized.[2]

Two points need to be addressed concerning the benzene solubles and PNA results. First, NIOSH, at one time, recommended/used cyclohexane for solvent extraction of PNA samples.[7] This was based on consideration of the health effects of benzene. Subsequently, NIOSH has modified this so that when possible bulk samples of dust or high volume air samples are extracted using several solvents (i.e. benzene, cyclohexane, acetonitrile) and then using the most effective solvent for extracting air samples.[1] For this study benzene was found to be the solvent of choice. The second point is that that benzene solubles were evaluated at the asphalt site even though the NIOSH criteria is 5 mg/m^3 of petroleum asphalt fume. Based on more recent research, asphalt has similar properties to coal tar pitch and thus the NIOSH investigators believe it is prudent to use the benzene soluble criteria for both coal tar pitch and petroleum asphalt.

B. Medical

1. Demographic data

Demographic data are summarized in Table 10. Twenty-one (78%) of 27 roofers at sites 1 and 2 were Mexican-American, two were white, and four were black. Their ages ranged from 18-61 (mean 33 years, median 29 years). Duration of employment as roofers ranged from two weeks to 33 years (mean 9.5 years, median 5 years). Of the 27 roofers, hair color was black in 15, brown in 10, blond in one, and not recorded for one. Eye color was brown in 23, blue in two, hazel in one, and not recorded for one. The data for the five workers at the Koppers (single ply) site are also shown.

2. Symptoms

Symptoms reported during the month prior to the survey: Symptoms most frequently experienced by the roofers during the month prior to the NIOSH survey were eye irritation, reported by 22 (81%), and skin irritation reported by 18 (67%). The eye irritation was described as burning, redness, tearing and, at times, grittiness. The skin irritation was characterized as redness like a sunburn, worse in the sun, occasionally with peeling by the 3rd or 4th day. Exposed areas were involved: face, lips, neck, arms, hands. The eye irritation was generally attributed to CTP, not to petroleum asphalt. One worker felt fibrous glass in the insulation also contributed to his symptoms. Similarly, the skin irritation was attributed to CTP, rather than asphalt, with three persons also implicating fibrous glass. The fibrous glass caused redness and itching in non-exposed body surfaces such as the trunk and back. In comparison, of the five workers installing the single-ply roof, the symptoms most frequently reported for the month prior to the survey were nose irritation (by three), and shortness of breath (by three) (Table 11). None of the four non-roofers interviewed reported any of the symptoms during the prior month.

Symptoms reported on the days of the survey: On day 1 (site 1), the sky was clear and sunny (data from National Weather Service in Table 12). Table 12 shows that of the 13 roofers at the CTP site who were interviewed at the end of the day regarding symptoms on that day, skin burning was reported by nine, tingling sensation of skin by nine, skin itching by eight, burning of the eyes by six, and tearing by six. NIOSH personnel were also symptomatic, with burning of the eyes reported by three of five, and burning or redness of the skin by all five.

On the second day, at the CTP site, the roof was watered down prior to starting work; the day was overcast (National Weather Service data in Table 12). Of the 10 roofers at this site interviewed at the end of the day, symptoms of skin burning were reported by five workers (two noted symptoms to be less severe than the previous day and one noted them to be more severe), and eye burning was reported by two. At the asphalt site (site 2), there were fewer roofers reporting symptoms (Table 12). On this day, NIOSH personnel experienced very few symptoms.

Aggravating factors: Factors that were reported to aggravate the symptoms associated with roofing work included white race, windy days, bright days, and exposure to CTP rather than petroleum asphalt. However, there was a mixed response regarding whether application (heated process) or tear-off (dusty, non-heated) caused more problems.

Personal protective equipment: Use of gloves was very common. Use of goggles was reported only by five (19%) of 27 roofers but wrap-around sunglasses were commonly worn. Respirator use was reported by three of 27. A half-mask respirator with organic vapor cartridge was worn by a kettleman, and disposable dust masks were used by two helpers. The latter two reported buying these themselves, although the supervisor reported that the contractor would supply them. Nine (33%) reported using either petroleum jelly or various commercial sunscreens. All took showers after work, and about one-half wore their work clothes home.

3. Signs on physical examination

Signs observed on physical examination can be classified into those possibly associated with pitch (acute or chronic chemical effects or physical effects due to hot pitch); and those not attributed to pitch (acute or chronic traumatic effects).

Attributed to pitch and asphalt:

Acute effects (observed on the days of the survey) are displayed by day and by site in Table 12. Acute effects were limited to observations of redness (tearing was also noticed but was noted as a reported symptom regardless of whether it was observed at the end of the day). The prevalence of observed effects was greater at the CTP site on day 1 (sunny, roof not watered down) than on day 2 (overcast, roof watered down). Of the six roofers observed to have eye redness, one had gross conjunctivitis (inflammation of the lining of the eyes) and photophobia despite wearing goggles on that day; his job title was that of helper.

Chronic effects: General (widespread) signs noted included aging of the skin and livido "network" marking that may be associated with chronic heat and UV exposure. Specific lesions noted included degeneration of the cartilage of the ear (chondrodermatitis helicis which can occur in sun-damaged skin) in one worker; hordeolum or meiobomian gland cysts (which can develop secondary to chronic inflammation of eyelids and lining of the eye) in one; warts or squamous acanthomas in three (on back of hand, eyelid and forearm), in three; dark brown dome-shaped lesions likely to be nevi (or possibly squamous acanthomas or warts) in one, keratin cysts (acne lesions) in one, and multiple fibreopithelial polyps (skin tags) in one. The mean and standard deviation for duration of employment as a roofer in the seven individuals with specific chronic lesions, 15.1 + 8.3 years, was greater than that in the 20 without such lesions, 7.6 + 9.4 years ($t=1.93$, $df=25$, <0.05 p <0.10). All seven with chronic lesions had greater than two years employment, while 13 of 20 without such lesions had worked this long ($p=0.087$, Fisher's exact test, one-tailed). It has been reported that two years experience with pitch is required to get chronic lesions such as pitch warts.[9] However, while the warts observed have been associated with pitch, the other lesions probably resulted from mixed exposures, particularly sun damage.

Burns also resulted from the physical effect of hot pitch and asphalt. Scars from old burns were observed in 14 (52%) of the 27 workers at the two sites, on various parts of the body, usually the forearms, wrists, and hands. A blister in one roofer and a healing scar from a recent burn in another were also noted.

Not attributed to pitch and asphalt: One roofer had lost his left eye during work as a roofer when a load of tear-off dumped over the side of a roof had struck a limb of a tree which then rebounded, striking his eye. Evidence of other acute trauma (cuts, abrasions, injuries to finger nails) were commonly observed. Calluses were also observed in at least five of the 27 roofers, suggesting chronic mechanical trauma to the hands.

VI. DISCUSSION AND CONCLUSION

Based on these results, the NIOSH investigators have concluded that a health hazard existed for employees exposed to PNAs at both the petroleum asphalt and CTP roofing sites. Additionally the benzene soluble portion of the samples were in excess of the NIOSH criterion (100 ug/m^3) on most of the personal samples at all three sites. This is true even when these partial shift samples are averaged over a full 8-hour TWA. Employees at the Koppers roofing site were exposed to detectable levels of perchloroethylene, which NIOSH considers to be a potential human carcinogen. HCl was not detected on any samples, and only one of five personal samples had detectable amounts of PNAs. Spraying the roof with water, which was done on day 2 at the pitch site, appeared to be an effective technique to reduce airborne emissions and, thus, personnel exposures.

The medical results indicate a high prevalence of reporting chronic eye and skin irritation, which appeared to be due to coal tar pitch. These effects appeared compatible with photosensitivity reactions associated with the pitch. Substantial proportions also suffered from acute symptoms as well; tearing and redness were present on the days of the study. Acute symptoms were more prevalent on sunny days, and less common at the asphalt site, compatible with reported aggravating factors. During a previous study, NIOSH investigators noted that the development of symptoms could be related to other variables in addition to the type of material and degree of pitch exposure; these included sun, wind, and activity such as tear-off.[23] In this study, tear-off was not routinely identified as causing more problems than application. Workers in the single-ply system experienced different symptoms than those at the classical sites, probably associated with solvents involved.

Chronic lesions (warts) that have been associated with pitch exposure were observed.

NIOSH has conducted 23 previous Health Hazard Evaluations during which roofing materials were evaluated.[14-36] Of these, 15 involved roofing system application, and the other 8 were in plants manufacturing roofing systems. Chemical exposures evaluated in the previous roofing system application studies varied according to the type of system being applied. In general, when compared to occupational exposure criteria, personal exposures have been higher at the hot, build-up, roofing sites than at single-ply roofing sites (Table 13).

Safety hazards are also of concern at roofing sites. The nature of roofing activities - many jobs last a week or less, roofing sites are unfamiliar, and the work is often at heights of 15 ft or more - enhance the possibility of accidents. NIOSH and other organizations have published information addressing these concerns.[37-44]

VII. RECOMMENDATIONS

Recommendations to minimize contact with pitch

1. Personal hygiene is very important. Showers should be taken, when feasible, after work each day. Preferably, work clothes should not be taken home and there should be a change of clothes after showering.

2. Fresh work clothes should be worn each day.

3. Under ideal conditions, skin contaminated with pitch dust and fume should be washed promptly with soap and water. However, as this is not practical at the work site, waterless cleansers should be used.

4. Personal protective equipment should include long-sleeved shirts which are tight fitting at the wrists, full-length pants extending to the shoes, goggles, gloves, and respirators.

5. Roofers should stay upwind of the pitch dust and fume as much as possible.

6. Before tear-off, roofs should be wetted thoroughly to minimize airborne particulate concentration.

Recommendations to minimize exposure to UV light

1. It is possible that the use of sunscreens containing benzophenones can decrease the amount of UV radiation reaching the skin. These should be applied approximately one-half hour before work and at mid-shift break. However, sunscreens can increase the adherence of coal tar pitch and petroleum asphalt particulate, thereby aggravating the skin irritation effect. As much exposed areas of the skin as possible should be covered to minimized exposure to UV radiation and to CTP and petroleum asphalt particulates.

2. Efforts should be made to avoid working during the hours when the UV radiation from the sun is most intense (usually from about 11 a.m. to 3 p.m.) where this is feasible.

Medical surveillance

Roofers who are usually exposed to pitch fumes and dust should have periodic medical evaluations, including a medical and occupational history and physical examination of the skin and eyes.

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2. United Union of Roofers, Waterproofers, and Allied Workers, Washington, D.C.
3. United Union of Roofers, Waterproofers, and Allied Workers, Local No. 116, Houston, Texas
4. OSHA, Region IV

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Figure 1

Name, Chemical Formula, and Structure of PNAs
Evaluated for in Personal Samples

Houston Roofing Sites
Houston, Texas
HETA 83-210

April 12, 1983

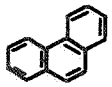
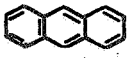
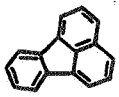
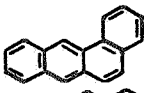
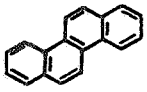
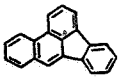
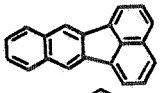
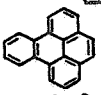
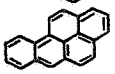
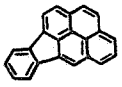
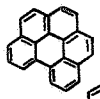
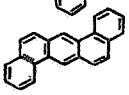
Name	Acronym (as used in report)	Formula	Structure
Acenaphthylene	ACL	$C_{12}H_8$	
Acenapnthene	ACE	$C_{12}H_{10}$	
Fluorene	FLU	$C_{13}H_{10}$	
Phenanthrene	PHE	$C_{14}H_{10}$	
Anthracene	ANT	$C_{14}H_{10}$	
Fluoranthene	FLE	$C_{16}H_{10}$	
Pyrene	PYR	$C_{16}H_{10}$	
Benzo(c)Phenanthrene	BCP	$C_{18}H_{12}$	
Benzo(a)Anthracene	BAA	$C_{18}H_{12}$	
Chrysene	CHR	$C_{18}H_{12}$	
Benzo(b)Fluoranthene	BBF	$C_{20}H_{12}$	
Benzo(k)Fluoranthene	BKF	$C_{20}H_{12}$	
Benzo(e)Pyrene	BEP	$C_{20}H_{12}$	
Benzo(a)Pyrene	BAP	$C_{20}H_{12}$	
Indeno(123-cd)Pyrene	INP	$C_{22}H_{12}$	
Benzo(ghi)Perylene	BGP	$C_{22}H_{12}$	
Dibenz(a,h,)anthracene	DAH	$C_{22}H_{14}$	

Table 1

Sampling and Analytical Methods

Roofing Sites
Houston, Texas
HETA 83-210

April 1983

Material	Sampling Train	Analytical Method
PNAs-during application	XAD sorbent tubes in combination with 37 mm teflon filters. Tube and filter attached to pump calibrated 1.0 at LPM	Tubes were desorbed in 5 ml of benzene with sonication for 30 minutes. The extract was filtered through a 0.45 um nylon filter and an aliquot of the filter solution was analyzed via gas chromatography. Standards were prepared by spiking aliquots of a stock solution containing 17 specific PNAs into XAD tubes and desorbing them following the same procedure.
PNAs-during tear-off	Teflon filters attached to a battery-operated pump calibrated at 1-2 LPM	Filters were placed in screw-cap vials with 0.5 ml benzene and sonicated for 30 minutes. The extracts were filtered through a 0.45 um nylon filter. An aliquot of each extract was transferred into a tared teflon cup and evaporated to dryness in a vacuum oven at 40°C. The teflon cups were weighed again and the difference recorded. The weight gain of the cup equals 1/5 of total benzene solubles per sample. The analysis was performed following NIOSH technical bulletin no. TB-001- with modifications.
Total Weight	Teflon filters attached to battery operated pump calibrated at 1-2 LPM with pump calibrated at LPM.	After equilibration, filters were reweighed to obtain the weight of the filter plus dust sample. Previously determined tare weight was subtracted to obtain weight of dust sample.
Perchloroethylene	Charcoal tube attached to battery operated pump calibrated at 0.2 LPM	A and B sections of each sample were separated and analyzed by gas chromatography using NIOSH method S-355 with modifications. Limit of detection was calculated to be 0.01 mg/sample.
Hydrochloric Acid	Treated silica gel tube attached to battery operated pump calibrated at 0.2 LPM	Samples were analyzed using ion chromatography according to NIOSH method no. P&CAM 339. A gravimeteric conversion factor of 1.02% was used to convert chloride to hydrochloric acid.

PNA Air Concentrations During Installation of a Coal-Tar Pitch Roof
Houston Roofing Sites; Houston, Texas
HETA 83-210
April 11, 1983

Sample No.	Worker	Time of Sample	Volume (liters)	Air Concentration (ug/m^3) Total wt.	Benzene Solubles	ACE	FLU	PHE	ANT	FLE	PYR	BCP	BAA	CHR*	BBF BKF	BEP	BAP*	Other PNAs Detect.	Total PNAs
ZP20	Worker A	942-1555	373		214	ND	ND	ND	ND	ND	ND	1.1	ND	ND	ND	ND	ND	None	1.1
XAP1	kettleman	942-1555	373			4	2.6	13.9	ND	1.2	0.59	ND	ND	ND	ND	ND	ND	Yes	24.5
Z3	Worker B, TO	907-1147	320	1590	310	ND	ND	ND	ND	1.1	1.2	ND	1.0	0.9		ND	ND	None	5.3
Z1	Worker C, TO	909-1226	394	4240	200	ND	ND	0.9	ND	1.2	1.2	ND	0.9	0.8	0.9	ND	0.63	None	6.5
ZP36	Worker D, AP	1122-1533	131		990	ND	ND	7.6	7.6	22.9	18.3	ND	8.4	17.6	11.5	4.5	3.9	None	102
XAP6	Spreader	1122-1533	131			91.6	26	122	9.2	24.4	13	ND	ND	ND	ND	ND	ND	None	286
Z2	Worker D, TO	909-1121	264	110		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP33	Worker E, AP	1120-1542	142		1400	ND	ND	ND	ND	2.1	2.3	ND	2.7	2.5	2.0	ND	ND	None	11.5
XAP3	Hot Carrier	1120-1542	142			16.2	5.1	16.2	ND	3.3	1.9	ND	ND	ND	ND	ND	ND	None	42.7
Z6	Worker E, TO	909-1118	258	1120	310	ND	ND	1.4	ND	2.0	1.8	ND	1.8	1.4	1.9	ND	1.3	None	11.7
Z4	Worker F, TO	909-1110	242	410	210	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP34	Worker F, AP	1110-1546	156		320	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
XAP4	& Mopper	1110-1546	156			32.7	9.6	23.1	2.1	4.1	2.6	ND	ND	ND	ND	ND	ND	None	74.2
ZP32	Worker G, AP	1135-1543	128		1170	ND	ND	2.8	2.0	4.8	4.1	ND	3.1	2.7	4.0	ND	ND	None	23.6
XAP2		1135-1543	128			25.8	7.8	14.8	ND	2.4	1.3	ND	ND	ND	ND	ND	ND	None	52.2
ZP29	Worker H, AP	1116-1545	538		240	ND	ND	0.54	ND	0.86	0.84	ND	0.54	0.5	0.52	ND	ND		3.8
Z5	Mopping	909-1226	394	1940	*250	ND	ND	0.74	ND	1.22	0.69	ND	0.86	0.71	0.86	ND	ND	None	5.1
ZP35	Worker I, AP,	1113-1544	151		530	ND	ND	2.8	2.6	4.9	4.9	ND	2.8	2.7	3.2	ND	1.8	None	25.7
XAP5	insulation	1113-1544	151			28	7.9	21	1.9	2.9	1.5	ND	ND	ND	ND	ND	ND	None	62.6
Z7	Worker I, TO, SHOV	906-1112	252	16030	710	ND	ND	8.3	4.8	11.5	8.7	0.99	6.7	5.6	8.3	4.4	5.6	Yes	71.9
ZP21	Worker J, AP, IS	1144-1544	480		170		ND	ND	0.88	1.48	1.5	ND	0.6	1.2	1.1	ND	ND	None	6.7

Note: Letters are used to designate different employees on same shift, identical letters on different tables do not represent the same workers.
AP = application, TO = tear-off, SHOV = shoveling, IS = insulation.
Arithmetic mean for 7 total particulate samples = 3530 ug/m^3 (roof was wetted).
Exposure criteria: 0.1 mg/m^3 for up to a 10 hr TWA (cyclohexane soluble fraction) - NIOSH.**
0.2 mg/m^3 for an 8 hr TWA (benzene soluble fraction) - OSHA and ACGIH.

* ACGIH has designated this chemical as a A2 Carcinogen.
** NIOSH has modified the laboratory technique such that several solvents are tested and the most effective solvent is used for field air samples. Benzene is often the solvent of choice.

Table 3

PNA Air Concentrations During Installation of a Coal-Tar Pitch Roof
Houston Roofing Sites; Houston, Texas
HETA 83-210
April 12, 1983

Sample No.	Worker	Time of Sample	Volume (liters)	Air Concentration (ug/m^3) Total wt.	Benzene Solubles	ACE	FLU	PHE	ANT	FLE	PYR	BCP	BAA	CHR*	BBF BKF	BEP	BAP*	Other PNAs Detect.	Total PNAs
XAP-48	Worker A	721-1230	309	-	-	23.6	2.9	20.7	2.4	3.2	1.6	ND	ND	ND	ND	ND	ND	Yes	63.5
ZAP-48	kettleman	721-1030	309	-	2520	ND	ND	1.3	ND	7.8	6.1	ND	3.2	3.2	3.2	6.2	2.6	Yes	35.9
Z-19	Worker B, TO	736-1040	368	1010	220	ND	ND	ND	ND	ND	ND	ND	1.1	0.7	ND	ND	ND	None	1.8
Z-25	Worker C, TO	736-1016	320	1440	940	ND	ND	ND	ND	ND	ND	ND	4.7	4.4	3.1	ND	11.9	Yes	32.8
XAD-300	Worker D, AP	1214-1412	118	-	-	6.0	2.29	12.7	2.2	3.55	2.2	ND	ND	ND	ND	ND	ND	None	29
Z-30		1212-1412	118	1530	2970	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.63	None	7.6
Z-22	Worker E, TO	736-1031	350	<30	140	ND	ND	.74	ND	1.3	1.3	ND	.97	.83	1	ND	ND	None	6.1
Z-23	Worker F, TO	736-1146	500	1320	240	ND	ND	0.8	ND	1.2	1.2	ND	1.0	.6	1	ND	0.8	None	6.6
Z-29	Worker F, AP	1220-1433	266	<30	564	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
Z-24	Worker G, TO	736-1145	378	1130	476	ND	ND	1.06	ND	1.59	1.59	ND	1.06	0.79	1.85	ND	1.32	None	9.3
Z-20	Worker H, TO	736-1027	342	610	2780	ND	ND	ND	ND	ND	1.2	2.3	2.2	ND	ND	ND	ND	None	1.2
Z-21	Worker H, AP	1214-1412	236	550	340	ND	ND	1.8	3	3.1	ND	1.2	2.3	2.2	ND	ND	ND	None	13.6

Note: Letters are used to designate different employees on the same shift, identical letters used on different tables do not represent the same workers.
AP = Application, TO = Tear-off
If two samples were collected on one employee simultaneously PNA for both samples should be added, for example Worker A has an exposure of 99.4 (63.5 + 35.9) ug/M^3 during application.
Arithmetic mean for 9 total particulate samples = 853 ug/m^3.

Exposure criteria: 0.1 mg/m^3 for up to a 10 hr TWA (cyclohexane soluble fraction) - NIOSH.**
0.2 mg/m^3 for an 8 hr TWA (benzene soluble fraction) - OSHA and ACGIH.

* ACGIH has designated this chemical as a A2 Carcinogen.
** NIOSH has modified the laboratory technique such that several solvents are tested and the most effective solvent is used for field air samples. Benzene is often the solvent of choice.

Table 4

PNA Air Concentrations During Installation of an Petroleum Asphalt Roof
Houston Roofing Sites; Houston, Texas
HETA 83-210
April 12, 1983

Sample No.	Worker	Time of Sample	Volume (liters)	Air Concentration (ug/3) Total wt.	Benzene Solubles	ACE	FLU	PHE	ANT	FLE	PYR	BCP	BAA	CHR*	BBF BKF	BEP	BAP*	Other PNAs Detect.	Total PNAs
	Worker A	825-1146																	
ZP108	kettle operator	1242-1433	310	-	740	ND	ND	ND	ND	3.55	3.55	ND	2.58	3.55	2.9	1.29	2.9	None	19
XAP108	"	825-1146	310	-	-	9.03	5.48	45.2	6.45	9.35	4.83	ND	ND	ND	ND	ND	ND	None	80.3
	"	1242-1438																	
ZP101																			
Z10	Worker B, mh	750-1144	468	<25	110	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP102																			
Z9	Worker C, TO, sw	751-1154	486	190	880	ND	ND	ND	ND	0.62	0.82	ND	ND	ND	ND	ND	0.62	None	2.06
ZP100																			
Z12	Worker D, TO, mh	754-1149	470	<25	430	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP103																			
Z11	Worker E, TO, li	756-1142	448	<25	220	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP104																			
Z13	Worker F, TO, li	757-1142	450	<25	560	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
Z15	Worker G, spr	808-1148	442	<25	110	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
Z14	Worker H, li	800-1141	442	<25	410	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND

TO = tear-off, AP = application, mh = material handler, li = laying insulation, spr = spreader
Letters are used to designate different workers, identical letters on different tables do not represent same workers.
Note: Simultaneous samples on worker A should be added for total exposure, his exposure was 99.3 (19 + 80.3) ug/m^3 for total PNAs.

Exposure criteria: Asphalt fumes = 5 mg/m^3 for up to a 10 hr TWA - NIOSH.
Asphalt fumes = 5 mg/m^3 for an 8 hr TWA - ACGIH.

* Designated as an A2 carcinogen by ACGIH.

Table 5

PNA Air Concentrations During Installation of an Petroleum Asphalt Roof
Houston Roofing Sites; Houston, Texas
HETA 83-210
April 14, 1983

Sample No.	Worker	Time of Sample	Volume (liters)	Air Concentration (ug/m^3) Total wt.	Benzene Solubles	ACE	FLU	PHE	ANT	FLE	PYR	BCP	BAA	CHR*	BBF BKF	BEP	BAP*	Other PNAs Detect.	Total PNAs
ZP760	Worker A,	728-1555	507	-	1440	ND	ND	2.56	2.56	16.4	13.4	1.32	5.12	5.92	7.5	3.74	4.14	Yes	75.1
XAD76	Kettleman	728-1555	507	-	-	3.16	2.37	19.7	1.76	2.37	1.83	ND	ND	ND	ND	ND	ND	Yes	35
Z46	Worker B, TO, scp	714-1205	582	400	223	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
Z42	Worker C, TO, scp	714-1204	580	550	224	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
Z35	Worker D, TO, scp	716-1117	484	480	165	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
Z33	Worker E, TO, pc	716-1117	482	330	270	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
Z41	Worker F, TO, scp	716-1116	480	1040	729	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP87	Worker F, AP	1305-1443 1456-1559	161	-	1120	ND	ND	2.05	6.83	9.32	7.45	4.29	4.16	7.45	14.9	ND	ND	None	56.5
XAD87	Worker F, AP	1305-1443 1456-1559	161	-	-	16.8	5.9	52.8	6.1	5.34	2.98	ND	ND	ND	ND	ND	ND	None	89.9
Z40	Worker G, TO foreman	732-1123	462	360	173	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP85	Worker G, AP, foreman	1309-1559	340		294	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP88	Worker H, AP	1302-1558	176	-	<BLD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
XAD88	Worker H, AP	1302-1558	176	-	-	8.52	3.69	4.03	21.6	9.66	5.68	ND	ND	ND	ND	ND	ND	None	53.2
ZP8	Worker I, AP	1310-1554	328	-	244	ND	ND	ND	ND	ND	ND	2.5	ND	ND	ND	ND	ND	None	2.5

Note: Letters are used to designate different workers on the same shift, identical letters on different tables do not represent same workers. For worker with simultaneous samples, the exposures for both samples should be added. For example worker A had a total PNA exposure of 110 (75 + 35) ug/m^3)

Exposure criteria: Asphalt fumes = 5 mg/m^3 for up to a 10 hr TWA - NIOSH.
Asphalt fumes = 5 mg/m^3 for an 8 hr TWA - ACGIH.

* Designated as an A2 carcinogen by ACGIH.

Table 6

PNA Air Concentrations during Installation of an Petroleum Asphalt Roofing System
Houston Roofing Sites; Houston, Texas
HETA 83-210
April 15, 1983

Sample No.	Worker	Time of Sample	Volume (liters)	Air Concentration (ug/m^3) Total wt.	Benzene Solubles	ACE*	FLU	PHE	ANT	FLE	PYR	BCP	BAA	CHR	BBF BKF	BEP	BAP	Other PNAs Detected	Total PNAs
ZP93 Z26	Worker A "	728-1042 "	388 "	- 410	464	ND	ND	ND	ND	ND	ND	3.61	ND	ND	0.95	ND	ND	None	4.56
ZP90 Z39	Worker B "	720-1102 "	444 "	- 720	338	ND	ND	ND	ND	0.9	ND	3.38	ND	ND	ND	ND	ND	None	4.28
ZP91 Z31	Worker C "	720-1100 "	440 "	- 660	750	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP92 Z45	Worker D "	720-1101 "	442 "	- 500	452	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	None	ND
ZP94 Z27	Worker E "	724-1042 "	396 "	- 660	505	ND	ND	ND	ND	ND	ND	11.1	ND	ND	ND	ND	ND	None	11.1

Letters are used to designate different workers on one shift, identical letters on different tables do not represent same workers.
*All reported PNA concentrations are in ug/m^3 (microgram per cubic meter)

Exposure criteria: Asphalt fumes = 5 mg/m^3 for up to a 10 hr TWA - NIOSH.
Asphalt fumes = 5 mg/m^3 for an 8 hr TWA - ACGIH.

* Designated as an A2 carcinogen by ACGIH.

Table 7

PNA Air Concentrations During Installation of a Koppers Roof
Roofing Sites; Houston, Texas
HETA 83-210
April 14, 1983

Table 8

Summary of Air Concentrations for Individual PNAs Detected in Personal Air Samples
Houston Roofing Sites; Houston, Texas
HETA 83-210
April, 1983

	Koppers				Asphalt				Coal Tar Pitch			
	Samples		Range		Samples		Range		Samples		Range	
	Total No.	No. Detected	Lo	Hi	Total No.	No. Detected	Lo	Hi	Total No.	No. Detected	Lo	Hi
Acenaphthylene	5	0	ND	ND	24	1	ND	3.7	24	2	ND	7
Acenaphthene	5	0	ND	ND	24	4	ND	16.8	24	8	ND	91.6
Fluorene	5	0	ND	ND	24	4	ND	5.9	24	8	ND	26
Phenanthrene	5	0	ND	ND	24	4	ND	54.9	24	17	ND	21
Anthracene	5	0	ND	ND	24	5	ND	21.6	24	9	ND	16.8
Fluoranthene	5	0	ND	ND	24	6	ND	18.8	24	19	ND	47.3
Pyrene	5	0	ND	ND	24	5	ND	15.2	24	19	ND	31.3
Benzo(c)Phenanthrene	5	1	ND	48	24	6	ND	11.1	24	3	ND	3
Benzo(a)Anthracene	5	0	ND	ND	24	3	ND	5.12	24	18	ND	8.4
Chrysene*	5	0	ND	ND	24	3	ND	7.45	24	18	ND	17.6
Benzo(b)Fluoranthene & Benzo(k)Fluoranthene**	5	0	ND	ND	24	4	ND	14.9	24	15	ND	11.5
Benzo(e)Pyrene	5	0	ND	ND	24	2	ND	3.7	24	3	ND	4.5
Benzo(a)Pyrene*	5	0	ND	ND	24	3	ND	4.14	24	10	ND	11.9
Indeno(123-cd)Pyrene	5	0	ND	ND	24	1	ND	9	24	2	ND	3.8
Benzo(ghi)Perylene	5	0	ND	ND	24	1	ND	3.6	24	2	ND	2.6

* = Designated an A2 carcinogen by ACGIH.
** = Results for these two PNAs were reported together by the analytical laboratory.

Table 9

Perchloroethylene Air Concentrations During Installation of a Koppers Roof

Houston Roofing Sites; Houston, Texas
HETA 83-210
April 14-15, 1983

Sample ID	Job/Location	Date	Sample Time	Volume (liters)	Air Concentration (mg/m^3)
CT-1	Employee A	4/14	1233-1616	41.9	2.39
CT-4	Employee B, zinger machine	4/14	1233-1447	38.6	2.07
CT-21	Employee C, prepare flashing	4/15	0830-0123	26.8	N.D. (0.42)

Note: HCl air samples were collected simultaneously with the perchloroethylene, HCl was not detected on any samples

Exposure criteria (mg/m^3): Mininize workplace exposure - NIOSH*
770 - OSHA
335 - ACGIH

*NIOSH considers perchloroethylene to be a potential human carcinogen, based on its ability to produce tumors of the liver in laboratory animals

Table 10

Demographic Data

Roofing Sites
Houston, Texas
HETA 83-210

April 1983

	Classical Tear-off and Application Sites	Single-ply System Site
Number	27	5
Race		
White/Black/ Mexican-American	2/4/21	3/-/2
Ages:		
Range	18-61	20-37
Mean (S.D.)	33(12)	
Duration of Employment:		
Current Job:		
Range	2 wk. - 22 yr.	5 mos. - 4 yr.
Mean (S.D.)	6 (7) yr.	
Median	2 years	
Total, as roofer		
Range	2 wk. - 33 yr.	5 mos. - 16 yr.
Mean (S.D.)	10 (10)	
Median	5 years	9 years

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