Coke oven emissions; CASRN NA

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the IRIS assessment development process. Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the guidance documents located on the IRIS website.

STATUS OF DATA FOR Coke oven emissions

File First On-Line 05/01/1989

Category (section)	Assessment Available?	Last Revised
Oral RfD (I.A.)	not evaluated	
Inhalation RfC (I.B.)	not evaluated	
Carcinogenicity Assessment (II.)	yes	05/01/1989

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Coke oven emissions
CASRN — NA
Primary Synonym — Coal tar pitch volatiles, as benzene soluble organics

Not available at this time

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Coke oven emissions
CASRN — NA
Primary Synonym — Coal tar pitch volatiles, as benzene soluble organics

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Coke oven emissions
CASRN — NA
Primary Synonym — Coal tar pitch volatiles, as benzene soluble organics
Last Revised — 05/01/1989

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Classification — A; human carcinogen

Basis — Studies of coke oven workers have shown increased risk of mortality from cancer of the lung, trachea and bronchus; cancer of the kidney; cancer of the prostate; and cancer at all sites

combined. In animals, extracts and condensates of coke oven emissions were found to be carcinogenic in both inhalation studies and skin-painting bioassays. The mutagenicity of whole extracts and condensates, as well as their individual components, provides supportive evidence for carcinogenicity.

II.A.2. Human Carcinogenicity Data

Sufficient. A statistically significant association between exposure to coke oven emissions and death from respiratory cancer was demonstrated in steelworkers in a cohort study in Allegheny County, PA, and in coke oven workers in other geographical areas of the United States and Canada. Workers exposed to coke oven emissions have also been shown to have an increased risk of mortality from cancer of the kidney, prostate, and all sites combined.

In a study of approximately 59,000 steelworkers, including 2800 coke plant workers, employed in 1953 at seven steel plants in Allegheny County, PA, Lloyd et al. (1970) found that nonwhite coke plant workers employed at least 5 years had a statistically significantly higher cancer mortality rate (40 observed, 19.6 expected) than the comparison group of steelworkers; most of the excess cancer mortality was due to lung cancer mortality (25 observed, 7.3 expected). Lloyd (1971) delineated a dose-response relationship for respiratory cancer by work area for nonwhite workers who had worked for 5 years or more and identified a difference in mortality for white and nonwhite workers. Respiratory cancer deaths among nonwhite workers were statistically significantly elevated, whereas the increase in respiratory cancer deaths for white workers was not significant.

Redmond et al. (1972) expanded the investigation of Allegheny County coke oven workers to include 10 selected steel plants throughout the United States and Canada. A statistically significant excess in respiratory cancer deaths was also found in all workers in the non-Allegheny County plants (33 observed, 20.7 expected). Deaths from malignant neoplasms of the genito-urinary system (mainly kidney and prostate cancer) were statistically significantly elevated among both nonwhites in the non-Allegheny County plants (10 observed, 5.7 expected) and among whites in the Allegheny County plants (5 observed, 0.9 expected).

Using data on the levels of benzene soluble organic material from different areas of the coke ovens at two Allegheny county steel plants, Mazumdar et al. (1975) found that the level of exposure and length of time exposed were both related to the development of cancer, particularly lung cancer. Cumulative doses to individual workers were calculated by multiplying the average exposure level (mg/cu.m total coal tar pitch volatiles) for a job site (oven topside, sideoven full-time, sideoven part-time) by the number of months worked at the job site, summed for all job sites at the oven. The average exposure levels used were 3.15 mg/cu.m for oven topside, 1.99 mg/cu.m for sideoven full-time, and 0.88 mg/cu.m for sideoven part-time. Cumulative exposure

(mg/cu.m - months) was divided into four categories: less than or equal to 199, 200-499, 500-699, and greater than or equal to 700 mg/cu.m - months. Age-adjusted data for the total number of nonwhite workers showed a clear dose-response relationship above 200 mg/cu.m - months for lung cancer mortality and for cancer at all sites. A dose-response was not seen for white workers. In a reanalysis of these data, however, U.S. EPA (1984) found little evidence to support the claim that a real sensitivity difference exists between whites and nonwhites. Due to the small number of white workers exposed to the highest reported exposure levels, it is unlikely that a statistically significantly difference between the white and nonwhite lung cancer mortality rates could have been detected.

In updates of the historical prospective cohort study begun by Lloyd et al. (1970), Redmond et al. (1976, 1979) found that Allegheny and non-Allegheny County coke oven workers employed through 1953 had a statistically significant excess of deaths from cancer at all sites, prostate cancer, and kidney cancer, in addition to the increased rates of cancer of the lung, trachea and bronchus seen in earlier studies.

Although specific information on smoking habits was not available for the studies reviewed above, the increase in mortality from lung cancer in the coke oven workers is considered too large to be attributed solely to a difference in smoking habits. Furthermore, any confounding due to smoking would tend to be reduced by the use of an internal comparison group of steelworkers, such as was done in these studies. It is possibile that synergistic effects between exposure to coke oven emissions and cigarette smoking contributed to the elevated mortality from lung cancer.

Sakabe et al. (1975) found that retired coke oven workers who had worked in iron and steel plants in Japan had an excess risk of lung cancer mortality when compared with the Japanese male population. The excess of cancer cases, however, may be attributable to differences in smoking habits. Because of inadequate smoking data, conclusions from this study are somewhat limited. Studies by Reid and Buck (1956) and Davies (1977) did not demonstrate the increased cancer risk in British steelworkers that had been found in the American and Japanese workers, but these British studies had some design limitations (such as short observation periods or small sample sizes) that may have prevented the detection of any cancer risks. In a study of workers at two French coke ovens, Bertrand et al. (1987) found that the death rate from lung cancer was significantly higher for these workers than for the general population.

The consistency of these epidemiologic results (that is, increased lung cancer incidence) adds to the weight-of-evidence that coke oven emissions are human carcinogens.

II.A.3. Animal Carcinogenicity Data

Sufficient. Animal studies contributing to the evidence of coke oven emission carcinogenicity have been conducted using extracts or condensates of coke oven emissions. Additional evidence is available from assays of incomplete combustion products similar in composition to coke oven emissions. Several inhalation exposure studies in laboratory animals have provided evidence of the carcinogenic effect of aerosols of coal tar and coal tar fractions.

Tye and Stemmer (1967) separated two different coal tars into phenolic and nonphenolic fractions and exposed mice by inhalation to various blends of the coal tar fractions and to one of the original tars. Test groups of 50 male C3H/HeJ mice, 3-5 months old, were exposed for 2 hours every 3 weeks for 55 weeks. The exposure concentration was reduced from 0.20 to 0.12 mg/L after 8 weeks because of excessive mortality at the higher dose. Adenomas and adenocarcinomas of the lung were observed in 60-100% of the mice inhaling coal tar aerosols, whereas tumors were not seen in any of the control mice.

McConnell and Specht (1973) reported on a study in which mice, rats, hamsters, and rabbits were exposed to a coal tar aerosol from which the light oil and solid fraction were removed. Male JAX-CAFl mice and ICR-CFl mice were exposed continuously for 90 days to concentrations of 0.2, 2, 10 or 20 mg/cu.m of coal tar aerosol, with 75 mice/group in the controls and at the highest dose, and 50 mice/group at the lower doses. Many of the mice, however, died from a streptococcus infection before the 93-day postexposure period had ended. A wide range of epithelial tumor types was seen, although squamous cell carcinomas predominated. In ICR-CFl mice, tumor responses of 0% (0/62), 0% (0/2), 8% (2/25), 38% (3/8) and 28% (10/36) were seen at concentrations of 0, 0.2, 2, 10 and 20 mg/cu.m, respectively. In JAX-CAFl mice, a tumor response of 37% (10/27) was found in the highest dose group, and no tumors were found in the other dose groups or in control animals. A time-to-tumor dose-response for the coal tar aerosol was also found. Ten percent of the exposed rat and hamster populations were sacrificed at the termination of coal tar aerosol exposure. Mild central lobular liver necrosis was observed in the exposed rats and hamsters. For the rabbits, internal pathology was not described. Lung tumors were not observed at any point during the study. Skin tumors occurred on two rabbits exposed to 10 mg/cu.m 8 days and 89 days after termination of exposures. The number of rabbits used in this part of the study was not stated.

MacEwen et al. (1976) exposed 75 female and 100 male ICR-CFl mice (described as tumor susceptible), 50 female JAX-CAFl mice (described as a tumor-resistant hybrid strain), 40 male and 40 female CFN strain Sprague- Dawley weanling rats, 18 New Zealand albino rabbits, and 5 male and 9 female Macaca mulatta monkeys to 10 mg/cu.m of coal tar aerosol for 6 hours/day, 5 days/week, for 18 months. Sixteen of 18 rabbits died from a respiratory infection during the exposure period, and no tumor data were presented for the monkeys. Alveolargenic [sic]

carcinomas were found in 43% (26/61) of the ICR- CFl mice (the "tumor-susceptible" strain) and in 54% (27/50) of the JAX-CAFl mice (the "tumor-resistant" strain). The number of tumors in the ICR-CFl and JAX-CAFl control mice were 4% (3/68) and 17% (8/48), respectively. The exposed and control groups did not differ in the incidence of other types of carcinomas, sarcomas, or adenomas. In rats, the incidence of squamous cell carcinomas in the lungs was 100% (38/38) in exposed males and 82% (31/38) in exposed females; no tumors were observed in male or female controls.

Nesnow et al. (1981) evaluated the effects of extracts of coke oven main samples in initiation-promotion and complete carcinogenicity studies in SENCAR mice (derived from mating Charles River CD-1 female mice with skin tumor- susceptible male mice). The extract was found to produce papillomas and skin carcinomas in the mice, and acted as an initiator, a promotor, and a complete carcinogen. An extract of topside coke oven emissions was also active as an initiating agent, although the extent to which this extract is representative of topside coke oven emissions is uncertain since the topside sample was contaminated with particulate matter from ambient air.

Numerous carcinogenicity studies have shown that coal tar samples applied topically to the skin of laboratory animals produce local tumors. These studies are reviewed in U.S. EPA (1984).

II.A.4. Supporting Data for Carcinogenicity

Solvent-extractable organic emissions from coke oven doors (U.S. EPA, 1977) and from the topside of coke ovens (Tokiwa et al., 1977; Huisingh et al., 1979; Mitchell et al., 1979) were found to be mutagenic in procaryote and mammalian cells in vitro. Solvent-extracted organics of particulates collected topside of a coke oven were found to cause DNA damage in a concentration-dependent manner as measured by sister chromatid exchange (Mitchell et al., 1979), and caused cell transformation in BALB/c 3T3 cells and in primary Syrian hamster embryo cells (Curren et al., 1979; Casto et al., 1979); however, these studies involve possibly significant contamination of the sample with ambient air particulates. Several polycyclic components identified in coke oven emissions have been shown to be mutagenic in a variety of tests (U.S. EPA, 1984).

In a study of topside coke oven workers (including 22 smokers, 8 exsmokers and 8 nonsmokers), polycyclic aromatic hydrocarbons, known to be coke oven emission constituents, were found in the subjects' urine. In addition the workers were shown to have benzo[a]pyrene diol-epoxide-DNA adducts in lymphocytes and antibodies to these adducts in blood sera (Haugen et al., 1986). In another study of 19 steelworkers exposed to coke oven emissions, material extracted from the urine of both smoking and nonsmoking workers was found to be more mutagenic than urine from control smokers and nonsmokers (DeMeo et al., 1987).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

None

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

II.C.1. Summary of Risk Estimates

Inhalation Unit Risk — 6.2E-4 per (ug/cu.m)

Extrapolation Method — Linearized multistage procedure

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	2E-1 ug/cu.m
E-5 (1 in 100,000)	2E-2 ug/cu.m
E-6 (1 in 1,000,000)	2E-3 ug/cu.m

II.C.2. Dose-Response Data for Carcinogenicity, Inhalation Exposure

Species/Strain — human, male
Tumor Type — respiratory cancer
Route — occupational
Reference — Mazumdar et al., 1975; Land, 1976

Respiratory cancer was considered the most appropriate basis for quantitation as it was the common finding among epidemiologic studies. U.S. EPA (1984) calculated an inhalation unit risk estimate based on the Lloyd- Redmond cohort data assembled by Mazumdar et al. (1975) and sorted by Land (1976). The total background U.S. death rate was used as a basis of comparison rather than the death rate for nonwhite males. A composite unit risk estimate of 6.2E-4 per (ug/cu.m) was obtained by calculating the geometric mean of the 95% upper bound estimates obtained for four latency periods (0, 5, 10 and 15 years). This value estimates the

human lifetime respiratory cancer death rate due to continuous exposure to 1 ug/cu.m of the benzene-soluble organics extracted from the particulate phase of coal tar pitch volatiles from coke oven emissions.

II.C.3. Additional Comments (Carcinogenicity, Inhalation Exposure)

The unit risk should not be used if the air concentration exceeds 2E+1 ug/cu.m, since above this concentration the unit risk may not be appropriate.

II.C.4. Discussion of Confidence (Carcinogenicity, Inhalation Exposure)

The Lloyd-Redmond cohort of steelworkers was sufficiently large and was followed for an adequate time period. The increases in respiratory cancer were statistically significant and dose-related. Factors that have the potential for biasing the calculated risk estimates are reviewed in U.S. EPA (1984). The population used to estimate lifetime risk consisted of black males working in physically demanding jobs in which they were exposed to coke oven emissions over part of their working lifetimes. The population at risk due to environmental exposures contains individuals of all sex-race combinations and levels of health, exposed from birth to death. The effects of age, sex, race, general health and cigarette smoking on the sensitivity of responses to coke oven emissions are unknown. The reliability of the exposure estimates made for members of the cohort are unknown. These estimates were based on measurements made in the 1960s in similar steel mills; these measurements were extrapolated into the past for 60 years.

The data of Land (1976) were sorted such that any exposure occurring within a specified "lag time" from a year of observation (i.e., O, 5, 10 or 15 years) was not included in the cumulative exposure total for that year. Since it is not known which of the lag times is most representative of reality, the geometric mean of the four different lag time risk estimates was used with the assumption that they are equally valid.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

II.D.1. EPA Documentation

Source Document — U.S. EPA, 1977, 1984

The 1984 Carcinogen Assessment of Coke Oven Emissions received Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 01/04/1989

Verification Date — 01/04/1989

Screening-Level Literature Review Findings — A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the cancer assessment for Coke oven emissions conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at hotline.iris@epa.gov or (202)566-1676.

II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or hotline.iris@epa.gov (internet address).

III. [reserved]
IV. [reserved]
V. [reserved]

VI. Bibliography

Substance Name — Coke oven emissions
CASRN — NA
Primary Synonym — Coal tar pitch volatiles, as benzene soluble organics

VI.A. Oral RfD References

None

VI.B. Inhalation RfD References

None

VI.C. Carcinogenicity Assessment References

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VII. Revision History

Substance Name — Coke oven emissions
CASRN — NA
Primary Synonym — Coal tar pitch volatiles, as benzene soluble organics

Date	Section	Description
05/01/1989	II.	Carcinogen summary on-line
12/03/2002	II.D.2.	Screening-Level Literature Review Findings message has been added.

VIII. Synonyms

Substance Name — Coke oven emissions
CASRN — NA

Primary Synonym — Coal tar pitch volatiles, as benzene soluble organics
Last Revised — 05/01/1989

- Coke oven emissions
- Coal tar pitch volatiles, as benzene soluble organics