V. BASIS FOR RECOMMENDED STANDARDS

Accumulated epidemiological evidence gathered in many countries and for various occupational groups conclusively demonstrates that workers intimately exposed to the products of the combustion or distillation of bituminous coal are at increased risk of cancer at many sites. These sites include cancer of the skin, [12] lung, [2,4,8,11,13-16,18] larynx, [18] nasal sinuses, [3,5] kidney, [14,16] bladder, [6,7,19] stomach, [11,14] intestine, [11] pancreas, [14] and blood forming organs (leukemia [14]).

While the increased cancer risk has been widely demonstrated, the exact causative agent or combination of agents in coke oven emissions has not been identified, nor has a dose-response relationship been established. The American Conference of Governmental Industrial Hygienists has recommended a Threshold Limit Value for coal tar pitch volatiles (benzene soluble fraction) of 0.2 mg/cu m as a level which, due to instability in the composition of the volatiles, should "minimize" exposure to the carcinogens present. [49] This same level has been adopted as the Federal standard for coal tar pitch volatiles and, as such, its applicability includes occupational exposure to coke oven emissions. However, in the absence of information on a safe level, this environmental standard can be considered only an index of worker exposure.

Although the threat to workers' health is not limited to benzene soluble compounds, the benzene soluble fraction of total particulates has been generally accepted as an index of the health hazard. Because

the polycyclic aromatic hydrocarbons in coke oven emissions are associated with the particulates [46] and are benzene soluble, that fraction may have some validity as a general index of the health hazard. On the other hand, the report by Laskin et al [45] at least suggests that the health hazard may be associated not with polycyclic hydrocarbons alone, but with polycyclic hydrocarbons and irritant gases in combination. If that is the case, then the usefulness of the benzene soluble fraction of total particulates as an index of the health hazard may be somewhat questionable. Additionally, this suggests the possibility that respiratory protection against gases as well as particulates may be needed if coke oven emissions cannot be reduced or eliminated through process changes, engineering controls, and operating procedures. At present, it appears that adequate respiratory protection is provided by particulate-removing respirators, especially if total emissions are reduced or eliminated, but additional research is needed to specifically demonstrate whether respiratory protection against gases is needed or not.

The type of respiratory protection to be provided and the conditions for its use can be based on an estimation of the health hazard as indicated either by some environmental measurements or by the area of employment. As discussed in the preceding paragraph, the traditional environmental index, the benzene soluble fraction of total particulates, is suspect as an index of the health hazard. Furthermore, there is no good evidence with which to determine a safe level of exposure, so that an environmental level could only be chosen

arbitrarily. On the other hand, the disease response has been correlated with the degree of exposure as determined by the area of employment. [16] Therefore, it is recommended that respiratory protection be based upon the area of employment, at least until information becomes available on which a meaningful environmental index and a safe exposure level can be established.

It is difficult to anticipate the performance of various filter media against particulate coke oven emissions. The AISI reported [46] that some filters, which allowed penetration of less than 10% when tested against 0.3 micron dioctylphthalate (DOP), performed poorly against coke oven emissions. Burgess [48] found that resin-impregnated deep wool batting allowed leakages up to 1.8% of total particulates (6.5% or less of the benzene soluble fraction). The next most efficient medium tested against coke oven emissions was a high-efficiency glass fiber-organic fiber filter, which allowed less than 0.02% penetration of DOP. Against coke oven emissions, the penetration was up to 6.3% of total particulates (up to 12.0% of the benzene soluble fraction). These reports illustrate the need for filter media to be tested specifically against coke oven emissions to verify their efficiency, which may not be the same as against another substance.

The AISI report [46] indicates that the quarter mask facepiece may be more acceptable to the workers than is the half mask since the former is more lightweight and cooler to wear due to its reduced seal area. However, the half mask is stabilized by the chin cup and the

facial seal often can be maintained despite facial movements during talking or involuntary facial movements during work. [46] With effective fitting and a choice of masks, the half mask will also fit most workers. Thus, while a good seal can be achieved with the quarter mask, it is less secure than is the seal with a half mask. For this reason, the quarter mask is not recommended for use on the coke ovens, since a good facial seal is critical to effective respiratory protection. A full facepiece offers a still better facial seal, but may be unacceptable for use in at least some jobs if vision is too restricted.

If opposition to a given respirator or facepiece type is encountered, the worker can be offered an alternative respirator in keeping with the provisions of Section 4, but most acceptance problems probably can be overcome as the worker becomes more accustomed to the use of respirators. Burgess [48] surveyed wearer acceptance of his experimental respirator and reported that workers' reactions to protective devices were modified by a number of factors, among them previous experience with such devices, the workers' impression of the hazard, and the employee relations "climate" at the plant. In general, if a worker was willing to wear the test respirator for an extended period, initial adverse reactions were mollified.

Although a dose-response relationship has not been established, the existence of such a relationship is suggested by findings that the increased risk for lung cancer is related both to exposure time and to degree of exposure as indicated by area of employment, [16] so that,

if exposures can be reduced, the incidence of disease should be reduced concurrently. Additionally, the type of cancer response appears to differ with the area of employment. While topside workers are reported to experience the higher lung cancer rate, nontopside coke oven workers are reported to have a higher rate for kidney cancer, [16] but nonoven coke plant workers apparently are at excess risk for cancer of the digestive system. [11]

Until information on which to establish a safe environmental level becomes available, the seriousness of the diseases associated with exposure to coke oven emissions makes prompt reduction of occupational exposures to the lowest practicable level important. Therefore, recommendations are made for more complete protection through a combination of operating procedures and respiratory protection. While it is felt that sufficient reliance cannot be placed on the environmental standard as measured by the benzene soluble fraction of total particulates (coal tar pitch volatiles), that standard should continue to be utilized to describe the environment and to assess the effectiveness of control methods, including process changes, because no better criterion is available.

Since safe exposure levels are unknown, equally important to the protection of the workers' health is regular medical evaluation, especially medical evaluation directed toward the early detection of those diseases for which coke oven workers have increased risk. This primarily involves cancer of three systems: the skin, respiratory and urinary systems. Early detection of cancers in these systems is a

primary objective of the medical program outlined in Section 2. Because the greatest excess risk, up to ten times the expected rate, [11,16] is for lung cancer, two medical examinations (X-ray and sputum cytology) specifically directed toward its detection are recommended. The only screening tests of proved, albiet insufficient, value in the detection of lung cancer, [49,50] these tests can be complementary in that cases missed by one method may be detected by the other. [50-53] This can be attributed to the observation that X-rays seem to be more accurate in regard to peripheral bronchogenic cancers, and sputum cytology seems more likely to be positive for cancers of the larger central bronchi. [50,51] Cytology appears to be more effective in the detection of early malignancies, [54] while it is estimated that approximately 60% of lung cancer's natural history precedes the earliest radiographic detection. [50]

False-positive and false-negative reports can occur with both methods. As suggested by Davies, [50] the effectiveness of sputum cytology can be affected by the accumulated experience of those conducting the screening tests. In nine reports in which there were fewer than 100 established cases of lung cancer, false-positives averaged 5.25%. In four studies with more than 250 cases each, false-positives averaged 2.9%, while in one study with 368 cases, false-positives were less than 1%. Chronic infection and inflammatory conditions were given as the predominant causes of the false-positive results. [50] On the other hand, radiologic false-suspects in screening programs can be greater. For example, in one mass-screening

chest X-ray program, the number of "lung tumor suspects" was over 14 times the number of cases eventually diagnosed. [55-57] Since it does not localize the lesion, positive sputum cytology with negative chest films presents a problem in medical management, but bronchoscopy, bronchial brushing, fiberoptic bronchoscopy, and differential cytology have been used successfully in localizing occult bronchogenic carcinomas. [51,58,59]

False-negative reports occur with both methods, as evidenced by the detection of lung cancer by one method but not the other, [53] and by follow-up studies which indicate lung cancer was present in an earlier screening but was missed then by both methods. [53] Several authors [51,53] point out that lung cancer or other anomalies can be visible, in retrospect, in X-rays but not noted by one or several reviewers in the initial screening. The success of sputum cytology is dependent upon obtaining a satisfactory specimen, which requires considerable skill on the part of the technician collecting samples. Consequently, false-negative cytology usually results from improperly collected specimens, lack of a good deep cough specimen, or obstruction in the bronchi, rather than misinterpretation since the skilled cytologist rarely misses malignant cells in the slide. [50] Both X-rays and sputum cytology, then, present difficulties of follow-up, false-negative results, and false-positive results; but, in view of their complementary nature, several authors recommend the use of both methods for screening high-risk populations. [50,52,53] Both methods are recommended here, because coke oven workers are a high

risk group. Methods for the handling and preparation of cytological samples and criteria for staging cells are discussed elsewhere. [60-62]

The occurrence of skin cancer has not been demonstrated to cause excessive mortality among American coke oven workers. Nevertheless, it has been well documented in the past among other workers exposed to the products of bituminous coal combustion or distillation. [12] It has been suggested that good personal hygiene in combination with prompt treatment of suspicious lesions can prevent all deaths due to skin cancer. [3] Therefore, regular dermatological examinations should be included in all medical examinations for the prompt detection and treatment of cutaneous cancers.

Excess kidney cancer has been reported in American coke oven workers [16] as well as in British workers in coke ovens and gas works. [14] Although excess cancer of the bladder has not been demonstrated in American coke oven workers, it has been reported in British gasworkers. [6,7,19] Beta-naphthylamine, which has also been identified in coal tar, [38] is present in the British workers' environment and has been suggested as the cause of the excess bladder cancer. [6,7] Regular urinalyses, including tests for red blood cells, can be helpful in the detection of cancer in the urinary system. Although hematuria may indicate cancer of the urinary tract, it may also derive from other causes, but it is a serious sign which must be further investigated. [63]

Excessive mortality due to cancer of the digestive system has been reported both in British coke oven and gasworkers [14] and in American coke plant workers. [11] Since the disease has not been demonstrated to be a cause of increased mortality among American coke oven workers, no specific screening procedure for its detection has been recommended. Nevertheless, physicians should at least be aware of the possibility of an increased incidence of digestive system cancers, and should thoroughly investigate any symptoms which could be indicative of cancer in that system.

Although primarily for guidance in respirator use, annual respiratory function evaluations should reveal evidence of some respiratory diseases. Additionally, respiratory function evaluations can assist in the placement of persons suffering from impaired cardio-pulmonary function.

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TABLE VII-1

TEMPERATURE RANGE OF CARBONIZING CHAMBERS
AND EXCESS OF LUNG CANCER REPORTED

Carbonizing Chamber	Temperature Range*	Percent Excess of Lung Cancer Reported
Vertical Retorts	400 - 500 C	27% [6]
Horizontal Retorts	900 - 1100 C	83% [6]
Coke Ovens	1200 - 1400 C	255% [11]
Japanese Gas Generators	1500 C	800% [11]

* References for Temperature: 9, 21-25

The figure shown for coke oven workers is for men with five or more years experience to provide contrast with the British gas workers who had worked at least five years at the retorts.

Table VII-2

Lung Cancer Mortality Rates for Selected US Smoking Groups[a], 1954-1962 and Steelworker Groups[b], 1953-1961

AGE	U. S. Smokers 35-44	45-54	55-64	65-74
	Steelworkers <45	45-54	≥55	
Never smoked, or only occasionally	-	-	10	30
Total cigarette smokers	5	42	138	281
Cigarettes smoked: 1 to 9 per day	-	-	53	132
Cigarettes smoked: over 39 per day	-	95	316	606
Steelworkers	12	127	162	
Coke oven, never topside	9	230	313	
Coke oven, topside	141	819	1,356	

a. Rate for U. S. smokers - Annual probability of death x 10^5

b. Rate for Steelworkers - (Probability of death, 1953-1961) x $10^5/9$

TABLE VII-3

SUMMARY OF EXPOSURES OF COKE OVEN WORKERS TO COKE OVEN EMISSIONS (BENZENE SOLUBLE FRACTION OF TOTAL PARTICULATES)

A SUMMARY OF SEPARATE AIR SAMPLING STUDIES BY AISI MEMBER COMPANIES AND PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES.

Operator (source of info.)	No. of Samples	Range* (mg/cu m)	Average** (mg/cu m)
Larry car operator			
AISI	106	0.78-6.4	2.2
PA	39	0.28-8.8	3.1
Lidman			
AISI	140	1.0-5.6	2.6
PA	61	0.42-18.	3.2
Door Machine Operator			
AISI	85	0.31-5.1	1.2
PA	25	0.04-6.5	2.1
Door Cleaner/Luterman			
AISI	172	0.31-3.2	1.1
Patcher			
AISI	10	0.71-1.3	0.99
Heater			
AISI	60	0.12-2.4	0.57
PA	39	N.D.-3.0	1.1
Quench Car Operator			
AISI	70	0.05-1.2	0.44
PA	23	N.D.-7.0	0.94
Pusher Operator			
AISI	78	0.15-0.82	0.40
PA	23	N.D.-0.93	0.39

* AISI DATA is a range of the mean coke oven emission concentrations reported for each job description by each coke plant studied.

** AISI DATA is the average of mean concentrations for each coke plant studied.

N.D. = None Detected

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