U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 75-177-343

HERSEY PRODUCTS COMPANY, INC.
DEDHAM, MASSACHUSETTS

NOVEMBER 1976

I. TOXICITY DETERMINATION

An evaluation of employee exposures to air contaminants found in the Bronze Foundry of the Hersey Products Company, Inc. in Dedham, Massachusetts has been conducted. National Institute for Occupational Safety and Health (NIOSH) investigators made visits to the facility on December 15-16, 1975 and April 20-21, 1976. The following determinations have been made with regard to potential hazards to employee health:

(1) A significant proportion (27%) of the personnel respirable samples in the coremaking, molding, shakeout and fettling areas showed exposures to crystalline silica in excess of the NIOSH recommended standard of 0.05 mg/m^3 and essentially all (92%) of the personnel samples exceeded the NIOSH recommended 0.025 mg/m^3 action level. Based upon (a) the measured personnel exposure concentrations of crystalline silica; (b) the recommended standard of the NIOSH Criteria Document for this substance; and (c) literature on the toxicity of this substance, it has been determined that the coremakers, molders, utility-men on shakeout and fettlers are exposed to potentially toxic concentrations of airborne respirable crystalline silica.

(2) Although the measured concentrations of formaldehyde, evolved from the exothermic curing and thermal decomposition of bonding agents used in the core sand, did not exceed the evaluation criteria, evidence exists that irritant toxicity to this substance is present in the exposed group of workers. Sixty percent of the oven-bake and shell coremakers reported irritation to conjunctiva and mucous membranes of the upper respiratory tract. Based upon (a) the high proportion of exposed workers reporting symptoms of irritation; and (b) the toxicological properties of this substance which may vary with each persons degree of sensitivity and/or susceptibility, it is determined that the shell and oven-bake coremakers are experiencing occasional acute irritant toxicity from exposure to airborne formaldehyde. Based upon (a) environmental measurements; (b) employee interviews and (c) available literature on the toxicity of phenol, carbon monoxide and hydrogen cyanide, it also is determined that these substances are not toxic to the coremakers at the levels found.

(3) Infrequent symptoms of nose and throat soreness elicited by two molders alledgedly resulting from exposure to toluene mist over-spray during mold spraying, are not expected at the levels of toluene reported. Based upon the (a) levels of toluene measured, (b) type and frequency of symptoms elicited, (c) number of persons eliciting the described symptoms, and (d) literature on the toxicity of toluene, it is determined that the molders are not exposed to toxic concentrations of toluene under the conditions of exposure studied.

(4) Bronze alloy furnace tenders and pourers are concurrently exposed to oxides of lead, copper, tin and zinc. A high proportion of the samples collected in the breathing zone of the tenders (25%) and pourers (80%) reported lead levels in excess of the 0.15 mg/m^3 NIOSH Recommended Standard for exposure to inorganic lead. With one exception, a furnace tender, all concentrations of copper fume were less than the 0.2 mg/m^3 TLV recommended by the ACGIH. The concentrations of tin and zinc reported were well below the selected evaluation health criteria. Based upon the (a) environmental levels measured and (b) toxicology of these inorganic metals, it is determined that: (1) The furnace tenders and metal pourers are exposed to potentially toxic levels of airborne inorganic lead. (2) The furnace tenders are exposed to potentially toxic concentrations of copper. (3) The furnace tenders and pourers are not exposed to toxic concentrations of zinc and tin.

(5) The metal pourer's exposures to formaldehyde, carbon monoxide, phenol and hydrogen cyanide resulting from thermal decomposition of the organic sand binders during pouring, are not toxic in the concentrations found. This is based on (a) environmental measurements, (b) employee interviews and (c) literature on the toxicity of these substances.

(6) Casting chipping and grinding personnel are exposed to inorganic metal particulates of lead, copper, zinc and tin. A significant proportion of the samples collected in the breathing zone of the chippers (75%) and grinders (33%) reported lead concentrations in excess of the 0.15 mg/m^3 NIOSH Recommended Standard for inorganic lead. Thirty-three percent of the chippers and 8% of the grinders reported copper dust concentrations in excess of the 1 mg/m^3 TLV recommended by the ACGIH. The measured levels of tin and zinc were well within the evaluation health limits. Based upon the (a) environmental levels reported and (b) toxicology of these inorganic metals, it is determined that: (1) The casting chippers and grinders are concurrently exposed to potentially toxic concentrations of lead and copper particulates. (2) Their exposure to zinc and tin particulate are not toxic under the conditions of exposure or concentrations found.

(7) The lead pot tender experienced negligible exposure to airborne inorganic lead for a two hour sample interim, which comprised the workers entire exposure period. Based upon (a) such casual melting of lead, (b) concentration of lead measured, and (c) a medical interview response, it is determined that the worker is not exposed to toxic concentrations of lead under conditions used or found.

Part VI of this report offers specific recommendations for (1) control of environmental exposures, (2) employment of personal protective equipment until engineering controls can be instituted or existing ones improved, and (3) medical and environmental surveillance programs.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Copies have been sent to:

a. Hersey Products Company, Inc., Dedham, Massachusetts
b. Authorized Representative of the International Molders and Allied Workers Union - Local Number 106
c. U.S. Department of Labor - OSHA - Region I
d. NIOSH - Region I

For the purpose of informing the approximately forty "affected employees", this Determination Report shall be "posted" for a period of at least thirty calendar days in a prominent place(s) readily available to the workers.

III. INTRODUCTION

Section 20 (a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669 (a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether a substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of Hersey Products Inc. according to provisions found in Section 20 (a)(6) of the Act to investigate potential exposures to (a) foundry sand and additives by seven coremakers, fourteen molders, and ten utility-men on casting and core-knockout; (b) metal fume by a lead pourer; and (c) 1,1,1-trichloroethane by a degreaser operator. Worker exposure to the latter degreasing solvent was not evaluated because of it's permanent discontinuance. Based on urine lead levels reported to NIOSH by the Hersey Products Company, assessment of metal fume and particulate exposures of two bronze alloy furnace tenders, three metal pourers, and twelve fettlers also were investigated, even though such were not mentioned in the request.

IV. HEALTH HAZARD EVALUATION

A. Process Description and Associated Potential Health Hazards

The company is engaged in the founding of bronze alloy castings for water meters. The processes used are similar to most foundry operations, i.e. pattern and core making, sand molding, alloy melting and pouring, shakeout and sand reclamation, and fettling. The health hazard evaluation study covers the listed operations, excluding pattern making. A brief description of the process stages and the associated potential health hazards follows:

1. <u>Core Making</u>: The cores are produced by the shell and oven bake processes. Two machines involving four workers (two per shift) employ the former process and one machine the latter entailing three persons (one per shift).

The shell cores are prepared from a phenol-formaldehyde resin-sand mixture. The fabrication process involves blowing the resin-coated sand into a metal mold pre-heated to 400°F, holding for approximately 30 seconds to allow the binder to polymerize, then removing the finished core or core segment from the mold. Formaldehyde, phenol, hydrogen cyanide and carbon monoxide are reported to be evolved from the organic binder system during curing[1]. The operator's principal exposure occurs during removal of the finished core from the mold and when carrying it to a storage table or rack beside the machine.

The oven-bake cores are prepared from a urea-formaldehyde resin-sand mixture blended with an oleoresinous binder to obtain the desired foundry characteristics of hot strength, collapsibility, and baking speed. The process involves a core turnover-draw machine and a dielectric baking oven. The operator shovels the resin-sand mix into the corebox and the jarring and jolting action of the machine compacts the sand mixture forming a core. The coremaker places the core on a conveyor belt leading into a ventilated oven pre-heated to 400 F for curing, which ranges from 6 to 25 minutes depending on core size. Exposures to airborne formaldehyde and phenol by the coremaker occur during the exothermic curing period of the core. The operator's principal exposure occurs at the outlet end of the oven during hand filing of the hot cores to remove minor blemishes and while lifting them from the conveyor onto a storage pallet.

In addition to the foregoing air contaminants, both coremakers also are exposed to crystalline silica particulate inherent to general workroom activities The siliceous sand used in core preparation was determined to have a crystalline silica content of around 95 percent.

2. Molding: Molding is accomplished by one large automatic, two inter mediate, and four small machines requiring fourteen persons (seven per shift). The sand molds are constructed using standard sifting, pneumatic compacting and manual finishing techniques. The process consists of compacting prepared sand around a pattern so as to leave an opening in the sand which reproduces the outside contours of the pattern; the cores are set in position within the opening left by the patterns; then the two mold sections are joined together. In order to improve the fluidity of the molten bronze alloy during pouring, each mold is sprayed with a compound containing around 60 percent toluene. The spraying period is usually less than 15 seconds. The molders are exposed to

vapors of toluene and silica dust. The latter substance is primarily generated by other foundry operations such as shakeout.

3. Melting and Pouring: The melting and pouring personnel consists of two furnace tenders and four metal pourers distributed in a one to two ratio, respectively, on two shifts. Three electric furnaces are used to produce the molten bronze alloy. Once the molten alloy has been heated to about 1900°F, the furnace is tilted upon its trunnions and the alloy flows into preheated ladles. From the ladles its discharged into small molds aligned in two rows and larger ones randomly positioned in a separate area. The small mold pouring station is provided with an over-head monorail system to which a movable exhaust duct and steel hood is affixed closely over the crucible of molten metal. The location of the large molds minimizes effective use of the traveling exhaust system, thus potentially increasing the pourers exposure to the evolved fumes and gases. The furnace tenders and metal pourers are exposed to the alloying elements of lead, copper, tin and zinc, and silica dust. The latter substance is generated by the adjacent shakeout operations and general foundry activity. In addition, the metal pourers also may be exposed to carbon monoxide, phenols, aldehydes, and hydrogen cyanide resulting from the thermal decomposition of the organically bonded sand[2,3].

4. Shakeout and Sand Reclamation: After a cooling period, the poured castings encased in their molds are moved to one of two locally exhausted shakeout grates or stations. One is used for small molds and the other for large molds. The former station is positioned along a conveyor line which automatically transports the castings to the shaker where an employee removes the castings and another the trays. The sand falls through the grating onto a conveyor belt which returns it to an automatic reclaim system or mullor for reprocessing. Overloading of the return sand conveyor belt usually results in a daily buildup of sand in a pit beneath the shaker which requires an employee, "janitor in the pit", to shovel the sand back onto the belt. Approximately ten utility-men are involved in the shakeout operation; however, normally no more than three to six persons are concerned with shakeout at anyone time. The shakeout process for the large molds is quite similar to that just described, except that an overhead crane maneuvers the molds to be shaken-out and the castings that have been shaken-out. The shakeout personnel are exposed to silica particulate.

5. Fettling: After the castings have been tumbled in a wheelabrator any remaining undesirable projections are removed by chipping and grinding in the finishing department. The department includes four chipping and six snagging booths, and three pedestal grinders operating one shift per day involving thirteen persons. The snagger-chippers remove the superfluous projections on the castings with power-operated chisels and any remaining rough spots and/or chisel marks are eliminated by hand held and/or pedestal grinders. The potential health hazards of the cleaning room personnel include airborne exposures to inorganic metal (lead, copper, zinc and tin) and mineral (crystalline silica) particulates.

B. Evaluation Design

On December 15, 1975, an initial environmental study survey was conducted at the plant by a team of NIOSH industrial hygienists. An entrance conference was held with representatives of labor and management to obtain background information about processes, materials, work schedules and employee profile. Subsequent to the briefing a walk-through orientation was conducted of the foundry and an environmental study protocol established to evaluate the potential health hazards identified and described in Part IV, Section A of this report. Environmental air monitoring was conducted in the core and molding departments, at the lead and bronze melting and pouring stations, and during casting shakeout and finishing activities. The contaminants monitored included urea and phenol-formaldehyde resin thermal decomposition products, crystalline silica dust, inorganic metal fumes and particulates, toluene and carbon monoxide.

Confidential medical questionnaires were completed on twenty-one of approximately forty "affected employees".

Because of (1) invalidation of the analytical results reported for the silica samples (due to high background levels of quartz measured on unexposed filters) and (2) levels of metal oxides and particulates measured in the breathing zone of two (2/12) fettlers which indicated that these workers may be exposed to toxic concentrations of inorganic lead and copper, an in-depth environmental follow-up study was conducted on April 20 and 21, 1976. The study included (a) re-evaluation of the coremakers, molders, utility-men and fettlers exposures to airborne free silica and (b) assessment of the fettlers, furnace tenders and metal pourers exposures to metal oxides and/or particulates. In addition to airborne lead, an attempt was made to use a biological criteria (urinary lead) as a second indice of exposure which would reflect total dose via inhalation and ingestion. However, due to insufficient sample data, this index was not used as an evaluation criterion.

C. Evaluation Methods

1. Environmental

Exposures to airborne crystalline silica, metal fumes and particulates, formaldehyde, phenol, toluene, carbon monoxide and hydrogen cyanide were measured using personnel and/or work area sampling techniques. The methods of collection and analysis for these substances are described below.

a. Crystalline Silica[4]: Personnel and high volume workroom respirable dust samples were collected using two-stage cyclone size-selective samplers. The personnel samples were collected in the workers breathing zone on a tared polyvinyl chloride (PVC) filter contained in a 2-piece cassette mounted in a

10 mm nylon cyclonic separator; air was pulled through the sampler at a rate of 1.7 lpm. The coreroom, shake-out area and small bench grinding room were established as high volume respirable dust sampling stations. The dust specimens were collected on a tared PVC filter contained in a 3-piece cassette mounted in a ½" steel cyclone; the flowrate was regulated at 9 lpm by a critical flow orifice. The filters were analyzed for total milligrams (mg) of crystalline silica by x-ray diffraction and the total dust determined by weight increase. Total milligrams of crystalline silica is meant to include all crystalline forms of silica such as quartz, cristobalite and tridymite.

b. Inorganic Metals (Lead, Copper, Zinc and Tin)[5]: The metals were concurrently collected on a tared PVC filter mounted in a 3-piece closed face cassette using a vacuum pump operating at 1.5 lpm. The metals were determined by wet ashing the filters in nitric acid and analyzing by atomic absorption spectrophotometry. The lower limit of analytical detection using the atomic absorption technique for lead, copper, tin and zinc was 0.002, 0.001, 0.005 and 0.001 mg per sample, respectively.

c. Toluene[6]: The levels of toluene during peak exposure times (such as pattern and mold spraying) were estimated with direct reading NIOSH certified Draeger gas detector tubes (Certification No. TC 84-050). Basically a certified tube must have ± 35% accuracy at ½ the exposure limit and ± 25% at 1 to 5 times the limit[7]. Based on the measured levels (<25 ppm), short term sampling was not conducted to address the 200 ppm ceiling value. Long term air sampling was completed by drawing air at 200 cc/min through a 150 mg activated charcoal tube to trap the contaminant vapors. The analyte was desorbed from the charcoal tube with carbon disulfide; the sample was separated with a gas chromatograph and analyzed with a flame ionization detector. The limit of detection was 0.01 mg toluene per sample using this analytical technique.

d. Formaldehyde[8]: Consecutive personnel and work area samples were collected by drawing air at a rate of 1 lpm through a standard midget bubbler containing 15 ml of a 1 percent sodium bisulfite solution. The exposed sodium bisulfite solution is acidified with a chromotropic acid-sulfuric acid solution to form a purple monocationic chromogen. The absorbance of the colored solution is read in a spectrophotometer and is proportional to the quantity of formaldehyde in solution. The lower limit of detection for formaldehyde was 0.1 ug per ml.

e. Phenol[9]: Consecutive personnel and work area samples were obtained by drawing air at a rate of 1 lpm through a standard midget bubbler containing 15 ml of 0.1 N sodium hydroxide to trap phenol vapors. The resulting solution was acidified with sulfuric acid and analyzed using a gas chromatograph with a flame ionization detector. The lower limit of analytical detection by this chromatographic technique was 0.03 mg phenol per sample. Draeger detector tubes were used to measure the levels at peak exposure times.

f. Hydrogen Cyanide and Carbon Monoxide[8]: The concentrations of hydrogen cyanide and carbon monoxide were measured with direct reading NIOSH certified Draeger detector tubes (Certification Nos. TC-84-052 and TC-84-045, respectively).

2. Medical Evaluation Methods

During the December 15 and 16, 1975 field investigation medical questionaires were completed on 21 of approximately 40 employees affected by the alledged health hazards. The interview was begun with a non-directed questionnaire in order to elicit any symptoms or medical problems of significant magnitude to come spontaneously to mind. A subsequent directed questionnaire was completed (16/21) only if the non-directed questionnaire response indicated a need for more specific questions.

D. Evaluation Study Criteria

1. Criteria for Assessing Workroom Concentrations of Air Contaminants

Two primary sources of criteria are used to assess workroom concentrations of the air contaminants evaluated: (1) NIOSH Criteria Documents on Recommended Occupational Health Standards and (2) Recommended and Proposed Threshold Limit Values (TLV's) and Their Supporting Documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1975. These criteria are based on the current state of knowledge concerning the toxicity of these substances and designed to protect individuals occupationally exposed to these substances for an 8-hour or up to a 10-hour workday, 40-hour workweek over a normal lifetime. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the evaluation criteria, a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness. The criteria are time-weighted averages for an 8-hour or up to a 10-hour exposure, except when preceeded by a C, which indicates a ceiling value defined for a short interval (usually 30 minutes or less).

In the following tabulation of criteria, the most appropriate value (in the opinion of this author) is presented with its reference and other information (such as OSHA standards) footnoted. The occupational health standards promulgated by the U.S. Department of Labor - OSHA (Federal Register, July 1, 1975, Volume 39, Title 29, Part 1910, Subpart Z, Section .1000) applicable to the substances measured for this determination are presented only to provide the employer with a perspective on the existing state of compliance or non-compliance with Federal regulation. Consequently, no discussion of their relationship to the contaminant levels measured will be presented.

However, due to the nature of the respirable silica OSHA health standard, the standard and corresponding exposure concentration for each sample have been calculated and presented in Tables II, III and IV. The OSHA standard should be compared to the total respirable dust concentration listed.

	Workroom Environmental Criterion			
	Time-Weighted Average (TWA)		Ceiling Value	Max. Duration
Substance	8-Hour	10-Hour		Minutes
[1] Crystalline Silica (Respirable Fraction)		50 ug/m^3		
[2] Lead and Its Inorganic Compounds	0.15 mg/m^3			
[3] Toluene	100 ppm		200 ppm	10
[4] Carbon Monoxide	35 ppm		200 ppm	
[5] Zinc Oxide Fume or Dust	5 mg/m^3		15 mg/m^3	15
[6] Copper Fume	0.2 mg/m^3			
[7] Copper, Dusts and Mists	1 mg/m^3			
[8] Tin Oxide	10 mg/m^3			
[9] Formaldehyde			2 ppm	
[10] Phenol-Skin	19 mg/m^3			
[11] Hydrogen Cyanide Skin	10 ppm			

[1] Reference: NIOSH Criteria Document (1974). Federal Occupational Health Standard (1975) for the respirable fraction is calculated by dividing 10 mg/m^3 by the % Quartz + 2. 8-hour T.W.A.

[2] Reference: NIOSH Criteria Document (1972). Federal Occupational Health Standard (1974) is 0.2 mg/m^3 8-hour T.W.A.

[3] Reference: NIOSH Criteria Document (1973). Federal Occupational Health Standard (1974) is 200 ppm 8-hour T.W.A. and 300 p.p.m. ceiling value.

[4]Reference: NIOSH Criteria Document (1972). Federal Occupational Health Standard (1974) is 50 p.p.m. 8-hour T.W.A.

[5]Reference: NIOSH Criteria Document (1975). Federal Occupational Health Standard (1974) is 5 mg/m^3 8-hour T.W.A.

[6]Reference: ACGIH TLV (1975). Federal Occupational Health Standard (1975) is 0.1 mg/m^3 8-hour T.W.A.

[7]Reference: ACGIH TLV (1975). Federal Occupational Health Standard (1974) is 1 mg/m^3 8-hour T.W.A.

[8]Reference: ACGIH TLV (1975). Federal Occupational Health Standard (1974) is 10 mg/m^3 8-hour T.W.A.

[9]Reference: ACGIH TLV (1975). Federal Occupational Health Standard (1974) is 3 ppm 8-hour T.W.A. and 5 ppm ceiling value.

[10]Reference: ACGIH TLV (1975). Federal Occupational Health Standard (1974) is 5 mg/m^3 8-hour T.W.A.

[11]Reference: ACGIH TLV (1975). Federal Occupational Health Standard (1974) is 10 p.p.m. 8-hour T.W.A.

2. Medical Evaluation Criteria

The medical criteria used to determine a toxic response to the substances under investigation consist of symptoms and signs which each agent produces when a toxic exposure occurs. A brief review of the known pathophysiological effects of the substances and supplemental references follows.

a. Crystalline Silica[4,11,12,13]: The most important health concern from excessive inhalation of crystalline silica is an increased potential for developing a form of pneumoconiosis ("dusty lung") termed silicosis. Silicosis has been defined as "a disease due to breathing air containing silica (silicone dioxide), characterized anatomically by generalized fibrotic changes in both lungs, and clinically by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis (some or all of which symptoms may be present), and by characteristic x-ray findings[12]". This form of pneumoconiosis usuallv develops after at least seven years of exposure, although a few cases have developed in as short a period of time as 1.5 years from inhalation of very high levels of silica with a high quartz content. At the other extreme, with exposure to low levels of free silica, more than twenty years may have to elapse before the disease develops to a stage when it can be diagnosed.

Early silicosis termed "simple silicosis" is usually first diagnosed by chest x-ray examination. At this stage there is little if any, functional impairment, and there are often no associated symptoms and signs. Symptoms occur when silicosis advances and becomes complicated by infection and emphysema. These changes are marked by intolerance to exertion, episodes of coughing, and production of thick sputum. When silicosis has progressed to this point, the chest x-ray is usually read as "conglomerate silicosis". Conglomerate silicosis many times progresses in spite of termination of exposure, becomes incapacitating to the affected worker, and is irreversible.

b. Inorganic Lead[14]: Lead poisioning may be acute or chronic; though it is more frequently chronic from lead accumulation in the body over a period of time. The symptoms of acute poisioning are experienced by a burning sensation in the mouth, stomach pain, nausea, vomiting and constipation or diarrhea. Chronic lead intoxication is slow and vague in its beginnings and the signs and symptoms are not well defined. At first, one may experience a general ill-feeling of fatigue, exhaustion, irritability loss of appetite and weight, vague abdominal discomfort, and a yellow discoloration of the skin. Sometimes a blue line of the gums is observed.

c. Toluene[6]: For an 8-hour exposure at 50-100 ppm, slight drowsiness and possibly slight headache may be noticed by some workers. At a level of 200 ppm unconditioned workers may complain of fatigue, muscular weakness, headache and nausea. At 200 to 500 ppm impairement of coordination, momentary loss of memory, and loss of appetite have been reported while 500-1000 ppm is strongly irritating to the eyes and respiratory system.

d. Zinc Oxide[15]: Inhalation of freshly formed fumes may produce a brief, self-limiting illness known as zinc chills, metal fume fever and brass founders chills. The symptoms usually occur a few hours after exposure. The symptoms include metallic taste in mouth, dryness of nose and throat, weakness, muscular and joint pains, fever, chills and nausea. These symptoms usually abate within 12 to 24 hours with complete recovery and temporary immunity. Therefore, workers are more susceptible on Mondays, than on other workdays.

e. Carbon Monoxide[16]: The inhalation of carbon monoxide causes asphyxiation by combining with hemoglobin to form carboxyhemoglobin which interferes with the oxygen carrying capacity of the blood. The effect of carbon monoxide (CO) exposure on man is enhanced by many environmental factors such as heavy labor, high environmental temperatures, and concomitant presence of narcotic solvents (such as methylene chloride) in the air breathed. Symptoms such as headache, nausea, fatigue and dizziness appear in healthy workers engaged in light labor near sea level when about 10% of the hemoglobin is combined with CO. Such a degree of saturation could be achieved by continually breathing air containing 50 ppm of CO for about 6 to 8 hours.

f. Copper Fume and Dusts[10]: Inhalation of copper fumes have been reported to produce signs and symptoms of metal fume fever characterized by chills, transient fever, nausea, thirst and exhaustion. Inhalation of dusts and mists of copper salts can result in congestion of nasal mucous membranes, pharynx, and on occasion, ulceration with perferation of the nasal septum.

g. Tin Oxide[10,17]: Prolonged inhalation of small amounts of tin oxide dust may result in production of pseudo-nodulation in the lungs which may be easily seen on the chest x-ray. This condition is referred to as stannosis and is considered to be nonprogressive and nondisabling. Inorganic tin compounds are relatively non-toxic and are not generally thought of as important industrial hazards.

h. Formaldehyde[10,18,19]: Irritation to the eyes, nose, mouth and throat are the most common worker health effects from inhalation of the gas. Formaldehyde has a very pungent odor which is detectable at levels less than 1 ppm; discomfort noted at 2-3 ppm when a tingling sensation in the eyes, nose and throat may be felt; and a burning of eyes, nose and throat with a difficult breathing at 10-20 ppm. Considerable variation in individual susceptibility to formaldehyde gas is noticeable. Some workers develop a physical tolerance to the irritant effects and work in concentrations intolerable to others, but others are markedly sensitive and may become more susceptible on repeated exposure. Dermatitis may result from contact with either liquid solutions or solid materials or resins containing free formaldehyde.

i. Phenol[10]: Due to relatively low volatility, phenol does not frequently constitute a serious respiratory hazard in industry. Dizziness, headache, delirium, muscular weakness, and cold sweat are common symptoms in severe cases of poisioning, which usually occurs through ingestion. Solid or liquid phenol can be absorbed thru the skin and can cause local tissue damage.

j. Hydrogen Cyanide[10]: This substance causes internal suffocation in the presence of abundant oxygen by preventing the body tissues from using it. The venous blood becomes cherry red. The effects of hydrogen cyanide on the system may develop suddenly as convulsions, coma and death at levels greater than 135 ppm; or an attack may cause irritation of eyes and mucous membranes, nausea, vomiting and diarrehea at levels around 100 ppm. Toxicity information suggest a break-point in the body's capacity to detoxify cyanide with increasing concentration aroud 100 ppm, although slight symptoms may occur after several hours of exposure to concentrations ranging from 20-40 ppm.