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THOMSON CONSUMER ELECTRONICS, INC.
CIRCLEVILLE, OHIO

NIOSH Investigators:
Gregory M. Kinnes, MS
Boris D. Lushniak, MD, MPH

I. SUMMARY

On May 17, 1989, the National Institute for Occupational Safety and Health received a request to determine if cancers among workers at Thomson Consumer Electronics, Circleville, Ohio, were occupationally related. NIOSH investigators visited the facility on August 7, 1989 and again on December 13-14, 1989. Thomson Consumer Electronics is a producer of glass components for television picture tubes.

Personal breathing-zone and general area air samples were collected for carbon monoxide, coal tar pitch volatiles (benzene soluble fraction), lead, metal oxides, polynuclear aromatic hydrocarbons (PNAs), and sulfur dioxide. For comparison, wipe samples from the lehr belts were collected to determine if the oxides present on the belt were the same as those collected in the air samples. A qualitative evaluation of the ventilation in the welding area was also conducted, and settled dust "bulk" samples were collected for asbestos analysis.

Five personal breathing-zone and three general area air samples were collected for coal tar pitch volatiles (CTPV) and PNAs in the glass molding area. The airborne concentrations of CTPVs ranged from non-detected to 0.19 mg/m^3. Only one of the three general area air samples had a detectable concentration (0.97 mg/m^3). Four samples had airborne concentrations above the NIOSH REL of 0.1 mg/m^3, and only an area sample exceeded the OSHA PEL of 0.2 mg/m^3. Only trace levels of four PNAs were detected: naphthalene, acenaphthene, fluorene, and acenaphthylene. The four general area air samples for sulfur dioxide and particulate sulfates, also collected from this area, had concentrations ranging from 0.008 to 0.082 ppm and 0.01 to 0.02 mg/m^3, respectively.

Ten personal breathing-zone samples were collected for lead from workers on the B lines, including: furnace operators, the ware handlers, and inspector/packers. The furnace operators and the ware handlers were thought to have the greatest exposure potential to lead.

The results for these samples ranged from non-detected to 248 ug/m^3. One area sample was also collected which had a lead concentration of 16 ug/m^3. Three of the ten samples (all collected from ware handlers) had concentrations above the OSHA PEL of 50 ug/m^3.

Seven bulk settled dust samples were collected from different air ducts or support beams and submitted for asbestos identification. All seven samples contained chrysotile asbestos. The amounts of chrysotile asbestos present ranged from 1 to 20 percent, with three samples containing 20% asbestos. These samples indicated that a potential hazard existed if the settled dust could become airborne where it could be inhaled.

Airborne and wipe sampling for metals identified five metals, all present at levels well below their evaluation criteria. These included chromium, iron, nickel, lead, and aluminum. A visual inspection of the welding room area showed that there was a potential for high exposures to welding fumes.

The review of records resulted in a list of 28 present or former employees with a diagnosis of various cancers or other major illness. The employees worked in a variety of departments and were diagnosed with their illnesses during the period 1981-1989. The diversity of the diagnoses and the variety of exposures make it difficult to associate any of these illnesses with specific workplace exposures.

Based on the data collected during this evaluation, NIOSH investigators concluded that there was insufficient evidence to associate the cancers and illnesses present in current and former Thomson Consumer Electronics, Inc. employees to workplace exposures. However, a health hazard existed from exposures to coal tar pitch volatiles and lead among press operators and ware handlers, respectively. Also, the identification of chrysotile asbestos in settled dust indicates sufficient contamination to warrant appropriate abatement. Recommendations concerning appropriate actions are included in Section VIII.

KEYWORDS: SIC 3229 (Pressed and Blown Glass and Glassware, Not Elsewhere Classified), cancer, lead, asbestos, coal tar pitch volatiles, polynuclear aromatic hydrocarbons, sulfur dioxide, sulfates, chromium, iron, nickel, carbon monoxide, welding, respirators.

II. INTRODUCTION

On May 17, 1989, the National Institute for Occupational Safety and Health received a request to determine if cancers among workers at Thomson Consumer Electronics, Circleville, Ohio, were occupationally related. This request was jointly submitted by Thomson Consumer Electronics and the International Brotherhood of Electrical Workers (IBEW).

NIOSH investigators visited the facility on August 7, 1989 and on December 13-14, 1989. During the visit on August 7th, an opening conference was attended by IBEW representatives, a management representative, and the corporate medical director. After this conference, a plant walk-through inspection was conducted, focusing on the areas of concern listed in the health hazard evaluation request: the mold shop; the maintenance shop; areas designated as lehrs A1, A2, B1, B2; the batch house; the forming areas; and the furnace rooms. Informal interviews regarding occupational health concerns were held with employees and supervisors, and pertinent records were reviewed.

The second visit, December 13-14, was conducted to characterize potential employee exposures to contaminants identified during the initial visit. Personal breathing-zone and general area air samples were collected for carbon monoxide, coal tar pitch volatiles (benzene soluble fraction), lead, metal oxides, polynuclear aromatic hydrocarbons (PNAs), and sulfur dioxide. For comparison, wipe samples from the lehr belts were collected to determine if the metal oxides present on the belt were the same as those collected in the air samples. A qualitative evaluation of the ventilation in the welding area was also conducted with the aid of smoke tubes. Because of concern for possible asbestos exposure, bulk samples of settled dust were also collected. Although asbestos-containing materials present in the plant were reported to have been previously removed, workers were concerned that it was present in the settled dust.

Initial findings were presented to management and union representatives at the conclusion of both site visits. Subsequently, status reports were distributed via letters on December 29, 1989 and January 16, 1990.

III. BACKGROUND

The Circleville, Ohio plant of Thomson Consumer Electronics manufactures glass panels and funnels used in the production of television picture tubes. These glass panels and funnels are manufactured separately on four process lines from two blast melting furnaces. These process lines all begin with batch materials used to make glass and end with either the finished panels or funnels. The completed panels and funnels are then shipped to another facility where they are assembled into actual television picture tubes. The facility employs approximately 560 employees and operates 24 hours a day, 7 days a week, on a four shift schedule.

The production processes used in the manufacture of the panels and funnels are very similar. Variations in the batch formulations of the glass and in the process applications are the only differences. Raw materials for the glass are received at the batch building, which houses various hoppers and silos where these materials are stored. This building is separate from the rest of the plant. The raw materials are mixed on a conveyor system which is almost completely automatic. The major ingredients are mixed together in different formulations depending upon whether the batch is used for funnel or panel glass. These ingredients include sand, soda ash, pot ash, potassium nitrate, strontium carbonate, nepheline syenite, barium carbonate, dolomite, limestone, and "Mexican" lead (litharge). Other materials also include cerium oxide, titanium dioxide, and sodium antimonate, which is handled manually. Silica and arsenic, previously used as raw materials when plant operations began in 1970, have since been eliminated. The use of silica was only partially eliminated at first, but was completely eliminated in early 1989. About 8000 pounds of raw materials are used per batch, and the plant typically runs 35-40 batches per day.

Mixed batches are transported to the furnaces in the main production facility via the conveyor system. At this point, the raw materials are fed into the blast melting furnaces to produce the molten glass used for the molding of the funnels and panels. Temperatures in the blast furnaces reach 1500°C. The molten glass is then dropped into molds to form either a funnel or panel. Sulfur and rubber, used in the molding process, may also be a source of potential employee exposures.

After the molding is completed, the glass funnels and panels are processed differently. The funnels are taken to a burnoff area by hot ware handlers where residuals from the molding process are removed. The funnel is then fused (seared) to a neck by heating with a gas flame in the neck sealer area. The funnels then are sent through final preparation steps before being loaded by robot onto the lehr belt.

Once on the lehr belt, the funnels are slowly cooled in a controlled oven. The lehr belt slowly conveys the funnels through the temperature gradient produced by the oven. As the funnels exit the oven at slightly above ambient temperature, they are inspected and then prepared for the finishing area. The funnels are wet finished using metal oxide, silicate and pumice products.

The panels are handled in a similar manner after the molding process. However, instead of having necks fused on by flame heating, four metal studs are inserted into the panels using radio-frequency (RF) units. After these studs are inserted, the panels are slowly cooled in an oven, in a similar fashion as the funnels. The panels are also inspected after exiting the oven and then taken to a finishing area. After finishing, the panels are code-dated by etching with aluminum oxide. At this point, both the panels and funnels are transported to another facility where they are assembled to produce a television picture tube.

IV. METHODS

A. ENVIRONMENTAL

Personal breathing-zone and general area air samples were collected for possible contaminants identified during the initial visit on August 7, 1989. These included samples for carbon monoxide, coal tar pitch volatiles (benzene soluble fraction), lead, metal oxides, polynuclear aromatic hydrocarbons (PNAs), and sulfur dioxide. A qualitative evaluation of the ventilation in the welding area was also conducted with the aid of smoke tubes.

Twelve personal breathing-zone (PBZ) and general area (GA) air samples were collected in the glass press area. Five PBZ and three GA air samples were collected for coal tar pitch volatiles (CTPVs) and PNAs according to NIOSH methods 5023 and 5515.(1) A 2-um pore size, 37-mm polytetrafluoroethylene (PTFE, Zefluor) membrane filter, followed by a washed XAD-2 sorbent tube (ORBO-43), were attached in series, via flexible tubing, to sampling pumps calibrated at a flow rate of 1.0 liter per minute (lpm). After sampling, the filters were removed from their cassette holders and placed in screw-cap vials. Both the vials and the sorbent tubes were wrapped in aluminum foil and shipped to the laboratory on ice, to prevent sample degradation from heat and UV prior to analysis. For CTPV analysis, the PTFE filters were placed in screw-cap vials with 5 milliliters (ml) of benzene and were sonicated for 30 minutes. The extract was filtered through a 0.45-um nylon filter and collected in an additional test tube. One ml of the sample was then transferred into a tared Teflon* cup and evaporated to dryness in a vacuum oven at 40°C. The Teflon cup was again weighed and the difference recorded, the weight gain of the cup being one-fifth the total benzene solubles per sample. The analytical limit of detection for benzene solubles was 0.05 mg per sample.

For PNAs, the ORBO-43 tubes were extracted by sonication for 30 minutes using 1 ml of benzene containing 30 ug/ml tricosane as an internal standard. This extract, and aliquots from the filter extraction, were both analyzed by gas chromatography according to NIOSH method 5515 with the following modifications:

Gas Chromatograph: Hewlett-Packard Model 5890 equipped
with a flame ionization detector.

Column: 30m x 0.32 fused silica capillary column
coated internally with 1.0 micron DB-5.

Oven Conditions: Temperature programmed from 100°C for 4
minutes up to 290°C at a rate of 4°C/minute
then held for 7 minutes.

The remaining four samples collected from the glass press area were four GA air samples for sulfur dioxide. These samples were collected using 37-mm mixed cellulose ester (MCE) filters followed by potassium hydroxide-treated (KOH) 37-mm cellulose filters at a pre-calibrated flow rate of 1.5 lpm, according to NIOSH method 6004. The samples were analyzed for sulfate ion concentrations by ion chromatography. The MCE and KOH treated filters from each sample were separately desorbed in 10 ml of eluent and allowed to stand with occasional shaking for 30 minutes. One drop of 30% hydrogen peroxide was then added to oxidize sulfite to sulfate. The KOH treated filters were also cleaned with Onguard-H* cartridges from Dionex due to interferences which caused a matrix effect. Aliquots of the resulting solutions from each filter were analyzed by a Dionex 2010i ion chromatograph equipped with a WISP 710B autosampler. Liquid standards covering the range 0.2 to 10.0 micrograms sulfate ion per milliliter were prepared and analyzed with the samples. The following instrumental conditions were used:

Eluent: 0.75 mM $NaHCO_3$/2.2 mM Na_2CO_3

Flow Rate: 2.0 ml/min

Detection Setting: 30 us (Full Scale)

Columns: HPIC-AG4A Pre-column
HPIC-AS4A Separator
AMMS-1 Membrane Suppressor

Eleven lead samples (ten PBZ and one GA air samples) were collected in the burnoff, neck sealer and furnace areas. The one GA air sample was collected at the entrance to a lehr oven. Six of the personal samples were collected from ware-handlers, two from the furnace operators, and two from inspector-packers. All were collected on cellulose ester membrane filters attached, via flexible tubing, to personal sampling pumps calibrated at 2 lpm. The filters were ashed with nitric acid and then quantitatively transferred to 10 ml volumetric flasks to be analyzed by atomic absorption spectroscopy according to NIOSH method 7082.

Five PBZ and two GA air samples were collected for metal oxides in the same manner as the lead samples. Two of the PBZ samples were collected from inspector packers while three were obtained from code daters. A GA air sample was collected from locations near both of these job classifications. The filters from these samples were digested and diluted to 25 ml according to NIOSH method 7300 and then analyzed using a Thermo Jarrell Ash ICAP 61 simultaneous scanning inductively coupled plasma emission spectrometer. Four wipe samples were also collected from the lehr belts using vinyl-coated paper tape to compare to metals identified in the air samples. These samples were wet-ashed and diluted with nitric and perchloric acids, filtered, and then analyzed by the same method as the air samples.

Five GA air samples for carbon monoxide were collected from the furnace day bins (3 samples) and the cullett elevators (2 samples). These were obtained using long-term, length of stain tubes attached, via flexible tubing, to sampling pumps with a calibrated flowrate of 20 cubic centimeters of air per minute (cc/min). Two qualitative samples for volatile organic compounds were also collected from the furnace day bins using activated charcoal tubes at a flow rate of 0.80 lpm. These samples were desorbed in 1 ml of carbon disulfide and then qualitatively analyzed by a gas chromatograph equipped with a mass selective detector to identify peaks.

Seven bulk dust samples were collected from various areas to be analyzed for asbestos content. Asbestos had previously been abated from the plant, but there was concern that asbestos may still be present in the settled dust. Portions of each bulk sample were immersed in Cargille Liquids and analyzed on an Olympus polarized light microscope at magnifications of 100x and 200x.

B. MEDICAL

The medical survey was conducted by holding informal interviews regarding health concerns with employees and supervisors. A compilation of illnesses was also performed by reviewing medical dispensary records, worker's compensation records, OSHA 200 logs, and records for medical leave of absence for the years 1980-1989.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 even though 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 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 becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Recommended Exposure Limits (RELs)(2), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs)(3), and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs)(4). The OSHA PELs, however, may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, 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 the lowest standard was used; however, industry is legally required to meet those levels specified by the 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 (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

A. COAL TAR PITCH VOLATILES - POLYNUCLEAR AROMATIC HYDROCARBONS

Polynuclear aromatic compounds (PNAs) are chemical species that consist of two or more fused aromatic rings. They are often associated with the combustion or pyrolysis of organic matter, especially coal, wood, and petroleum products. Some PNAs have been demonstrated to cause cancer in laboratory animals and, in some cases, humans. There are few dose related relationships for the PNA mixtures that may be found in these processes. Although the application of laboratory animal data for PNA compounds to estimate human risk is very difficult, any occupational exposure to potentially carcinogenic matter is a cause for concern, and exposures should be kept to an absolute minimum.

NIOSH recommends that occupational exposures to coal tar be controlled so that employees are not exposed to coal tar, coal tar pitch, creosote, or mixtures of these substances at a concentration greater than 0.1 milligram per cubic meter (mg/m^3) of the benzene- (or cyclohexane-) extractable fraction of the sample, determined as a TWA concentration for up to a 10-hour work shift in a 40-hour work week. Both the ACGIH and OSHA set their standards at 0.2 mg/m^3 for a normal 8-hour workday or 40-hour workweek. Individual PNA measurements serve to establish the presence of CTPVs and indicate the presence of known or suspected carcinogens or other genotoxic compounds in the workplace, which would dictate the need for additional control measures.

The potential adverse health effects of PNAs are well recognized.(5-8) Several PNAs, such as benzo(a)anthracene and pyrene, have been shown to be carcinogenic in animals. Excess risk 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. A TWA exposure of 0.2 micrograms per cubic meter (ug/m^3) of air was recommended by the coke oven advisory committee for benzo(a)pyrene under the OSHA 29 CFR 1910.1029 coke oven emissions standard, but was not adopted. A NIOSH hazard review of chrysene recommended that it be controlled as an occupational carcinogen.(6) Also, the ACGIH includes chrysene and benzo(a)pyrene in its list of industrial substances suspect of carcinogenic potential for humans. The carcinogenic potential of other PNAs (benzo(a)anthracene, anthracene, pyrene, and fluorothene) has also been documented.(6)

B. SULFUR DIOXIDE

Sulfur dioxide is irritating to the upper respiratory tract, and chronic exposure can cause runny nose, dryness of the throat, and cough. Long-term, low-level exposure can cause chronic bronchitis and reduced pulmonary function. In 1977, in testimony before the Department of Labor, NIOSH revised its REL for SO_2 from 5.2 mg/m^3 to 1.3 mg/m^3 (equivalent to 0.5 parts per million (ppm)).(9) This revision was based on epidemiologic and exposure data indicating acute and chronic health effects observed in the 2.6 to 13 mg/m^3 (1.0 to 5.0 ppm) exposure range. Consideration was also given to: 1) health effects observed among workers and experimental subjects in the 2.6 to 5.3 mg/m^3 (1.0 to 2.0 ppm) range, 2) the ten to 20 percent of the population who are especially susceptible to SO_2 effects, 3) the possibility that synergistic effects with other aerosols or gases may occur, 4) the possibility of an increased fraction of SO_2 reaching the lower lungs through mouth breathing or because of rapid or deep breathing, 5) the possibility that SO_2 may act as a cancer promoting agent, 6) the possible enhancement of effects by high humidity, and 7) the likelihood that degradation products (sulfites and sulfates) will accompany SO_2 exposure. The OSHA PELs for SO_2 are 5 mg/m^3 for an 8-hour TWA (equivalent to 2 ppm) and 13 mg/m^3 (equivalent to 5 ppm) for a 15 minute short-term exposure limit (STEL). The ACGIH TLVs for SO_2 are the same as the OSHA limits.

C. LEAD

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women. There is some evidence that lead can also impair fertility in occupationally exposed men.(10,11)The blood lead test is one measure of the amount of lead in the body and is the best available measure of recent lead absorption. Adults not exposed to lead at work usually have a blood lead concentration less than 30 microgram per deciliter (ug/dl); the average is less than 15 ug/dl.(12,13) In 1985, the Centers for Disease Control (CDC) recommended 25 ug/dl as the highest acceptable blood level for young children.(14) Since the blood lead concentration of a fetus is similar to that of its mother, and since the fetus's brain is presumed to be at least as sensitive to the effect of lead as a child's, the CDC advised that a pregnant woman's blood lead level be below 25 ug/dl.(14) Recent evidence suggests that the fetus may be adversely affected at blood lead concentrations well below 25 ug/dl.(15) Furthermore, there is evidence to suggest that levels as low as 10.4 ug/dl affect the performance of children on eductional attainment tests, and that there is a dose-response relationship with no evidence of threshold or safe level.(16,17) Lead levels between 40-60 ug/dl in lead exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60-100 ug/dl represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/dl are considered to be extremely dangerous and often require hospitalization and medical treatment.

The free erythrocyte protoporphyrin (FEP) level is a measure of interference with hemoglobin production at the time the red blood cells are made. Lead affects heme synthetase, the last enzyme in heme synthesis. Although some diseases and iron deficiency anemia can cause a rise in FEP, in a healthy individual working with lead, lead absorption is the most likely cause for such an increase. Further, the FEP level becomes elevated when the blood lead level reaches about 40 ug/dl in men and 30 ug/dl in women, and since the average life span of a red blood cell is 120 days, the FEP reflects the blood lead level over the preceding 3-4 months. Normal FEP levels are below 50 ug/dl.

The OSHA PEL for lead in air is 50 ug/m^3, calculated as an 8-hour time-weighted average for daily exposure. This regulation also requires semi-annual blood lead monitoring of employees exposed to 30 ug/m^3 or more of lead. An employee whose blood lead level is 40 ug/dl or greater must be retested every two months and be removed from a lead-exposed job if the average blood lead level is 50 ug/dl or more over a 6-month period. A blood lead level of 60 ug/dl or greater, confirmed by retesting within two weeks, requires immediate medical removal. Workers on medical removal should not be returned to a lead-exposed job until their blood lead level is confirmed to be below 40 ug/dl. The standard also recommends that the blood lead levels of employees planning to have children should be kept below 30 ug/dl. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 40 ug/dl and they can return to lead exposure areas.(10)

D. CHROMIUM

Chromium exists in a variety of chemical forms depending upon its valence state, a term simply describing the compound's atomic arrangement. It is necessary to specify the form of chromium because of the range of health effects that Cr compounds may cause. For example, elemental Cr (metallic Cr) is relatively nontoxic and does not produce allergic dermatitis.(18) Other chromium compounds can cause primary skin irritation, which can vary from a dry erythematous eruption to a weeping eczemza. These conditions are associated with prolonged exposure and would be less likely to occur following an isolated, low concentration exposure.(18) Chromium exposure can also result in skin sensitization and allergic dermatitis. Sensitization appears to be independent of the level of exposure.(19) Exposure to chromate salts has also been associated with the development of allergic asthma; this association has been seen in metal platers, who have a prolonged occupational exposure.(18)

In the hexavalent state (CrVI), Cr compounds are irritating, corrosive, and carcinogenic. Until recently the less water-soluble CrVI forms (i.e. lead and zinc chromate) were considered carcinogenic, while the water-soluble forms were not. Recent epidemiological evidence indicates carcinogenicity among workers exposed to soluble CrVI compounds.(20-24) Based on this new evidence, NIOSH recommends that all CrVI compounds be considered as potential occupational carcingens. NIOSH does not have RELs for other forms of chromium; however, the ACGIH has published a TLV of 0.5 mg/m^3 for chromium metal and compounds containing the CrII and CrIII valence forms.

E. IRON

Inhalation of iron oxide fume or dust is associated with an asymptomatic pulmonary disorder termed siderosis. Siderosis can produce chest x-rays indistinguishable from fibrotic pneumoconiosis; however, studies have failed to demonstrate a reduction in pulmonary function.(25) The ACGIH recommends a TLV of 5.0 mg/m^3 for an 8-hour TWA, while the OSHA PEL for iron oxide is 10 mg/m^3.

F. NICKEL

Nickel can exist in both soluble and insoluble forms. Epidemiologic evidence suggests that the hazard presented by insoluble nickel compounds is not as great as that presented by soluble forms. Nickel has been reported to cause "nickel itch," an allergic dermatitis. An increase in nasal, sinus, and lung cancer has been noted in workers employed in nickel refineries, although the specific carcinogenic agent is still not defined. Metallic nickel introduced into the pleural cavity, muscle tissue, and subcutaneous tissue has been shown to be carcinogenic in test animals. NIOSH considers inorganic nickel to be a carcinogen and, in a 1977 criteria document, recommended that personal exposures be kept below 15.0 ug/m^3, which is the lowest reliably detectable level for a full work shift sample.(26) However, current reasoning suggests that exposures be reduced to the lowest feasible level. Both the OSHA PEL and ACGIH TLV for nickel metal and its insoluble compounds are 1 mg/m^3. However, the ACGIH TLV is included in the 1990-1991 Notice of Intended Changes, which proposes a limit of 0.05 mg/m^3 and lists nickel compounds as confirmed human carcinogens.

G. CARBON MONOXIDE

Carbon monoxide (CO) is a colorless, odorless, tasteless gas produced by incomplete burning of carbon-containing materials. Major sources of human exposure to CO are engine exhaust, tobacco smoking, and inadequately-ventilated combustion products from appliances and heaters that use natural gas, propane, kerosene, or similar fuels. On inhalation, CO acts as a metabolic asphyxiant, causing a decrease in the amount of oxygen delivered to the body tissues. Carbon monoxide combines with hemoglobin (the oxygen carrier in the blood) to form carboxyhemoglobin, which reduces the oxygen-carrying capacity of the blood. It blocks oxygen from binding to hemoglobin and slows the release of oxygen to the tissues. Some CO is formed by metabolic processes in the human body.(27,28) The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, and nausea. These initial symptoms may advance to vomiting, loss of consciousness, and collapse, if prolonged or higher exposures are encountered. Coma and death may follow if high exposures continue without intervention. Long-term, low-level exposure to CO can increase the risk of heart attack for some people.(27,28)

The criteria used to evaluate occupational exposure to CO are:

OSHA	PEL 35 ppm TWA
NIOSH	REL 35 ppm TWA, 200 ppm Ceiling
ACGIH	TLV 50 ppm TWA, 400 ppm STEL

VI. RESULTS AND DISCUSSION

A. ENVIRONMENTAL

Tables 1-5 present the results from the environmental sampling conducted during this investigation. The results for the CTPVs and PNAs are presented in Table 1. The airborne concentrations for the five PBZ samples ranged from non-detected to 0.19 mg/m^3, while only one of the three GA air samples had a detectable concentration (0.97 mg/m^3). Of these eight samples, only four had detectable levels of CTPVs. The four samples with detectable levels had concentrations ranging from 0.12 to 0.97 mg/m^3, all of which are above the NIOSH REL of 0.1 mg/m^3. Only the area sample had a concentration above the OSHA PEL of 0.2 mg/m^3; however, all three of the personal samples were above what is generally termed the action level (0.5 x PEL). This is a level at which corrective actions, such as implementing engineering controls and periodic monitoring, should be considered. Only trace levels of four PNAs (naphthalene, acenaphthene, fluorene, and acenaphthylene) were detected. Naphthalene was the only PNA identified on five of the samples; acenaphthene was the only PNA on one sample; and one sample had fluorene and acenaphthylene at detectable levels. Also, no PNAs were detected on one sample. Naphthalene was present in the greatest amount of all the PNAs identified, with 1.6 ug being detected on one sample (3.6 ug/m^3).

The results for the sulfur dioxide and particulate sulfates are presented in Table 2. Four GA air samples were collected, with measured sulfur dioxide concentrations ranging from 0.008 to 0.082 ppm. The particulate sulfate concentrations ranged from 0.01 to 0.02 mg/m^3. The sulfur dioxide concentrations were all below both the NIOSH REL and the OSHA PEL. The results for particulate sulfate (SO_4^{-2}) represent the presence of total sulfate, in both ionic and molecular forms (including sulfuric acid [H_2SO_4]), impregnated upon airborne particulates. There are no evaluation criteria for total sulfates. Since any sulfates present will likely be no more irritating than H_2SO_4, the total sulfate concentrations may be compared with the evaluation criterion for H_2SO_4, resulting in a conservative evaluation of the exposure levels (erring on the side of safety). The measured airborne concentrations of particulate sulfates in this facility are, nevertheless, well below the evaluation criterion for H_2SO_4 (1.0 mg/m^3).

Table 3 presents the results of the airborne lead monitoring. Ten PBZ samples were collected from furnace operators, ware handlers and inspector/packers on the B lines. The B lines produce the funnel portion of the picture tubes, and the furnace operators and ware handlers were thought to have the greatest lead exposure potential. The raw material formulation for the glass used in this production line contains lead, while the formulation used for producing the panels on the A lines does not. However, one GA air sample was collected from the A2 line for comparison. The results for the PBZ samples ranged from non-detected to 248 ug/m^3, while the GA air sample collected from the A2 line had an airborne lead concentration of 16 ug/m^3. Six of the samples were collected from various ware handlers, with the results for these samples ranging from 4.1 to 248 ug/m^3. Two furnace operators were monitored, and the results for these samples were 18 and 31 ug/m^3. Two inspector/packers were also monitored, but only one had a detectable concentration of lead (2.2 ug/m^3). The exposure patterns were as expected, since the furnace operators and ware handlers are involved with hot processes where lead has the greatest chance of becoming airborne. Three of the ten samples (all collected from ware handlers) were above the OSHA PEL of 50 ug/m^3.

The results of the air and wipe samples for metals are presented in Table 4. Five PBZ and two GA air samples were collected and analyzed for airborne metals. The five PBZ samples were collected from two inspector/packers and three code daters, while one sample was collected from an area corresponding to each job title. Of the metals detected, five were listed in this table because of either quantity detected or toxicity. These include aluminum, chromium, iron, nickel, and lead. All five of these metals were detected in samples from inspecting/packing, while only aluminum and iron were detected in all the code dating samples except one. Lead was also detected in the code dating area sample. All these airborne concentrations were well below their respective evaluation criteria. Wipe samples, collected from the lehr belts, reflected the results of the air sampling. Chromium, iron, nickel, and lead were detected on all the samples. These metals were probably all in oxide form due to oxidation caused by the heat in the ovens. Aluminum was not detected on the wipe samples because the source of aluminum was probably the aluminum oxide used for code dating.

Table 5 presents the results of the bulk dust sample anaylsis for asbestos content. Seven bulk, settled dust samples were collected from different air ducts or support beams. All seven samples were identified as having a chrysotile asbestos content. The amounts of chrysotile asbestos present ranged from 1 to 20 percent, with three samples containing 20% asbestos. These samples indicate that a potential hazard exists if this settled dust can become airborne where it can be inhaled.

Of the five GA air samples collected for carbon monoxide, two samples collected from the cullett elevators both measured CO concentrations of 2 ppm, while three collected from the day bins were non-detected. All these results were below the evaluation criteria. The results of the samples for volatile organic compounds identified many common hydrocarbons, with the major constituent being toluene.

Based on observations of the ventilation system in the welding area using the smoke tubes, there is a potential for exposures to welding fumes. The Tungsten Inert-Gas (TIG) welding machine is ventilated by a single wall exhaust fan located directly behind the welding area. This fan reduces the potential for exposure to the welding fumes; however, the presence of cross drafts in this room reduce the effectiveness of this fan. Two other welding machines are also located in this room and rely on the wall exhaust fan to remove contaminants (i.e., they are not equipped with local exhaust ventilation). When these welding machines are operated simultaneously, the workers in this area may potentially be over-exposed to welding fumes. The remaining welding units are located directly outside of this room. These arc welding units are enclosed in booths and are equipped with local exhaust ventilation, which effectively reduces the potential for exposure.

B. MEDICAL

A review of records provided by the IBEW and by management, and of medical records available at the plant, resulted in a list of 28 present or former employees with a diagnosis of cancer or other major illness. Concern had been raised by the IBEW and management as to whether these illnesses could be work related. The list included the variety of illnesses shown in Table 6. The employees worked in a variety of departments and were diagnosed with their illnesses during the period 1981-1989. The diversity of the diagnoses and the variety of exposures make it difficult to associate any of these illnesses with specific workplace exposures.

VII. CONCLUSIONS

Based on the data collected during this evaluation, NIOSH investigators conclude that there is insufficient evidence to associate the cancers and illnesses present in current and former Thomson Consumer Electronics, Inc. employees to workplace exposures. However, a health hazard existed from exposures to CTPVs and lead in press operators and ware handlers, respectively. Also, the identification of chrysotile asbestos in settled dust indicates sufficient contamination to warrant appropriate abatement.

VIII. RECOMMENDATIONS

Preliminary recommendations made after the initial site visit were included in a letter dated December 29, 1989. These additional recommendations are made based on the environmental sampling results and observations. All of these recommendations will help to further reduce potential employee exposures.

1. Current projects set up by management to deal with problems of heat, noise, lead exposure, and cumulative trauma disorders should be continued. The lead exposure program should be developed according to OSHA standard, 29 CFR 1910.1025. This regulation requires semi-annual blood lead monitoring of employees exposed to airborne lead levels of 30 ug/m^3 or more. An employee whose blood lead level is 40 ug/dl or greater must be retested every two months and be removed from a lead-exposed job if the average blood lead level is 50 ug/dl or more over a 6-month period. A blood lead level of 60 ug/dl or greater, confirmed by retesting within two weeks, requires immediate medical removal. Workers on medical removal should not be returned to a lead-exposed job until their blood lead level is confirmed to be below 40 ug/dl. The standard also recommends that the blood lead levels of employees planning to have children should be kept below 30 ug/dl. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 40 ug/deciliter and they can return to lead exposure areas.

2. Improvements in ventilating the press, ware handling, and welding areas should be undertaken. These should emphasize the use of localized exhaust units to remove contaminants generated by these processes from the workers' immediate breathing zones. The contaminants generated during the TIG welding process can be removed by means of a low-volume, high-velocity exhaust system (extracting gun, see figure 1). Exposures at the other welding machines can be controlled using a welding bench-type exhaust ventilation. Examples of these types of ventilation systems were excerpted from the ACGIH's "Industrial Ventilation - A Manual of Recommended Practice", 20th edition, and are included in the appendix as figures 2 and 3. A variation of the welding bench (VS-416) ventilation design may applicable to the burnoff and neck sealing processes. In the glass press and molding area, enclosing and ventilating the press, where employees are not required to have continual access, should reduce the potential for exposure to both lead and CTPVs. An industrial exhaust

ventilation expert should be consulted during the design and implementation of any ventilation system to ensure that it operates properly and performs its intended task.

3. Special attention should be directed to the areas where there are complaints of dust exposure (lehrs, code dating). The re-evaluation of ventilation in these areas is encouraged. Hoses used for ventilation in the code dating area should be replaced when leaks occur.

4. In the interim, until engineering and administrative controls can be utilized to reduce employee exposures to CTPVs and lead, a repiratory protection program in accordance with 29 CFR 1910.134 and 29 CFR 1910.1025, and consistent with the guidelines found in DHHS (NIOSH) Publication No. 87-116, "A Guide to Industrial Respiratory Protection," should be implemented. Standard operating procedures should be developed concerning respirator selection, use, maintenance, respirator fit-testing, cleaning and storage.
5. The settled dust present on the air ducts and support beams should be removed using wet methods and vacuums equipped with high efficiency particulate air (HEPA) filters. This removal should be accomplished as soon as possbile, especially if there is potential for the dust to become airborne during events such as maintanance or renovation. If Thomson employees perform this removal, they should be properly trained in asbestos abatement according to the OSHA asbestos regulations (29 CFR 1910.1001 and 29 CFR 1926.58) and any applicable State regulations. If the removal is to be performed by an outside firm, a contractor qualified in asbestos abatement should be selected. A list of qualified contractors can be obtained from the following:

    A. Regional Asbestos Coordinator for the Environmental Protection Agency is available from the EPA:

    TSCA Assistance Office
    EPA, TS-799
    401 M Street, SW
    Washington, DC 20460

    B. Private Consultants - A list of industrial hygiene consultants who are members of the American Industrial Hygiene Association (AIHA) and AIHA-accredited laboratories can be obtained from the AIHA:

    American Industrial Hygiene Association
    475 Wolf Ledges Parkway
    Akron, Ohio 44311-1087

IX. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 3. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984. (DHHS (NIOSH) publication no. 84-100).

2. Centers for Disease Control. NIOSH recommendations for occupational safety and health standards 1988. Morbidity and Mortality Weekly Report 37, S-7. 1988.

3. American Conference of Governmental Industrial Hygienists. Threshold limit values and biological exposure indices for 1988-89. Cincinnati, Ohio: ACGIH, 1989.

4. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1989.

5. Harrison's Principles of Internal Medicine. Ninth Edition. New York, McGraw-Hill Book Company, pp 255-262, 1980.

6. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to coal-tar products. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. (DHEW publication no. (NIOSH) 78-107).

7. Herwin, R.L. and Effect, E.A. Health Hazard Evaluation Report No. 75-194-324. National Institute for Occupational Safety and Health, Cincinnati, Ohio 45336, 1976.

8. Gorman, R.W. and Liss, G.M. Health Hazard Evaluation Report No. 80-206-1164. National Institute for Occupational Safety and Health, Cincinnati, Ohio 45226, 1981.

9. NIOSH Testimony before the Department of Labor. Occupational Safety and Health Administration Public Hearings on the Occupational Standard for Sulfur Dioxide, May 1977.

10. Occupational Safety and Health Administration. Occupational exposure to lead--final standard, 29 Code of Federal Regulations Part 1910.1025. Federal Register, July 1, 1988.

11. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to inorganic lead (revised). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. (DHEW publication no. (NIOSH) 78-158).

12. Muhaffey K, Annest J, Roberts J, Murphy R. National Estimates of Blood Lead Levels. United States, 1976-1980. N Engl J Med 307, 573-9, 1982.

13. Annest J, Dirkle J, Makuc C, Nesse J, Bayse D, Kovar M. Chronological Trends in Blood Lead Levels Between 1976 and 1980. N Engl J Med 308, 1373-7, 1983.

14. Centers for Disease Control. Preventing Lead Poisoning in Young Children: Centers for Disease Control, 1985.

15. Bellinger D, Leviton A, Waternaux C, Needleman H, Rabinowitz M. Longitudinal Analysis of Prenatal and Postnatal Lead Exposure and Early Cognitive Development. N Eng J Med 316: 1037-43, 1987.

16. Fulton M, Hepburn W, Hunter R, Laxen D, Raab D, Thomson G. Influence of Blood Lead on the Ability of and Attainment of Children in Edinburgh. Lancet 1221-25, 1987.

17. Needleman, H.L. and Constantine, C.A.. Low-level Lead Exposure and the IQ of Children - A Meta-analysis of Modern Studies. J Am Med Assoc 263: 673-678, 1990.

18. Proctor, N.H. and Hughes, J.P.. Chemical hazards of the workplace. Philadelphia: J.B. Lippencott Company, 1988.

19. Doull J., Klaassen C., Amdur M.O., eds.. Casarett and Doull's toxicology: the basic science of poisons. 2nd ed. New York: Macmillan Publishing Company, Inc., 1980.

20. Blair, A. and Mason, T.J.. Cancer mortality in United States counties with metal electroplating industries. Arch Environ Health 35(2):92-94, 1980.

21. Franchini I., Magnani F., and Mutti A.. Mortality experience among chromeplating workers. Initial findings. Scand J Work Environ Health 9:247-252, 1983.

22. Royle, H.. Toxicity of chromic acid in the chromium plating industry (1). Environ Res 10:39-53, 1975.

23. Silverstein M., Mirer F., Kotelchuck D., Silverstein B., Bennett M.. Mortality among workers in a die-casting and electroplating plant. Scand J Work Environ Health 7 (Supplement 4):156-165, 1981.

24. Sorahan T., Burges D.C.L., and Waterhouse J.A.H.. A mortality study of nickel/chromium platers. Br J Ind Med 44:250-258, 1987.

25. American Conference of Governmental Industrial Hygienists. Documentation of the threshold limit values and biological exposure indices. 5th ed. Cincinnati, Ohio: ACGIH, 1986.

26. National Institute for Occupational Safety and Health. Criteria for a recommmended standard: occupational exposure to inorganic nickel. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW pulication no. (NIOSH) 76-164).

27. National Institute for Occupational Safety and Health. Occupational diseases - a guide to their recognition. Revised Edition. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHHS (NIOSH) publication no. 77-181).

28. National Institute for Occupational Safety and Health. A guide to the work-relatedness of disease. Revised Edition. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1979. (DHHS (NIOSH) publication no. 79-116).

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:
Gregory M. Kinnes, M.S.
Industrial Hygienist
Industrial Hygiene Section

Boris D. Lushniak, M.D., M.P.H
Medical Officer
Medical Section

Field Assistance:
Leo M. Blade
Industrial Hygienist
Industrial Hygiene Section

Analytical Support:
Measurements Development Section,
and Measurements Research and
Support Branch
Division of Physical Sciences and
Engineering
Cincinnati, Ohio 45226

DataChem
Salt Lake City, Utah

Originating Office: Hazard Evaluations and
Technical Assistance Branch
Division of Surveillance, Hazard
Evaluations, and Field Studies

XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Thomson Consumer Electronics, Inc., Circleville, Ohio
2. International Brotherhood of Electrical Workers, Local 12331
3. OSHA, Region V

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.

TABLE I

Personal Breathing-Zone and General Area Air Concentrations of Coal Tar Pitch Volatiles (Benzene Soluble Fraction) and Polynuclear Aromatic Hydrocarbons

Thomson Consumer Electronics, Inc.
Circleville, Ohio
HETA 89-244
December 14, 1989

Sample Description	Sampling Time (min)	Coal Tar Pitch Volatiles (mg/m3)	PNAs*
B1 Press Operator (PBZ)	432	0.19	naphthalene
B2 Press Operator (PBZ)	420	0.12	naphthalene
A1 Press Operator (PBZ)	338	ND	naphthalene
B1 Equipment Operator (PBZ)	396	ND	naphthalene
B2 Equipment Operator (PBZ)	450	0.18	naphthalene
East side of B1 Press (GA)	432	ND	acenaphthene
East side of B2 Press (GA)	445	0.97	fluorene and acenaphthylene
South side of B2 Press (GA)	438	ND	ND
EVALUATION CRITERIA	NIOSH OSHA ACGIH	0.1 0.2 0.2	

* Only trace amounts of the PNAs listed in this column were identified on their respective samples.

PBZ - personal breathing zone sample
GA - general area air sample
ND - not detected: limit of detection for CTPVs was 0.05 mg/sample
for individual PNAs was 0.5 ug/sample except dibenz(a,h)anthracene at 1.0 ug/sample

TABLE II

General Area Air Concentrations of Sulfur Dioxide and Particulate Sulfates

Thomson Consumer Electronics, Inc.
Circleville, Ohio
HETA 89-244
December 14, 1989

Sample Description	Sampling Time (minutes)	Sulfur Dioxide (ppm)	Particulate Sulfates (mg/m3)
West side of B1 Press	433	0.034	0.02
North side of B1 Press	427	0.082	0.02
Northeast side of B2 Press	441	0.040	0.01
North side of B2 Press	208	0.008	0.01
EVALUATION CRITERIA	NIOSH	0.5	---
	OSHA	2.0	---
	ACGIH	2.0	---

TABLE III

Personal Breathing-Zone and General Area Air Concentrations of Lead

Thomson Consumer Electronics, Inc.
Circleville, Ohio
HETA 89-244
December 14, 1989

Sample Description	Sampling Time (min)	Lead (ug/m3)
B Line Mix & Melt Furnace Operator	356	31
A&B Line Mix & Melt Days Furnace Oper.	356	18
B1 Forming Ware Handler	175	46
B1 Forming Ware Handler	413	82
B1 Ware Handler	409	60
B2 Hot Ware Handler	404	248
B2 Ware Handler	401	39
B2 Ware Handler	401	4.1
B1 Inspector / Packer	372	ND
B2 Inspector / Packer	378	(2.2)
Front Entrance to A2 Lehr Oven (GA)	341	16
EVALUATION CRITERIA	NIOSH OSHA ACGIH	<100 50 150

ND - not detected: limit of detection (LOD) was 0.8 ug/sample

( ) - value was between LOD and the limit of quantitation (2.5 ug/sample)

GA - general area air sample

TABLE IV

Personal Breathing-Zone, General Area Air and Wipe Sample Concentrations of Metals

Thomson Consumer Electronics, Inc.
Circleville, Ohio
HETA 89-244
December 14, 1989

Sample Description	Sampling Time (minutes)	Aluminum (mg/m3)	Chromium (ug/m3)	Iron (mg/m3)	Nickel (ug/m3)	Lead (ug/m3)
A1 Inspector / Packer	371	0.22	9	0.59	4	8
A2 Inspector / Packer	368	0.054	3	0.16	1	4
A1&2 Code Dater	368	0.027	ND	0.062	ND	ND
A1&2 Code Dater	365	0.027	ND	0.053	ND	ND
A1&2 Code Dater	323	0.015	ND	0.053	ND	ND
A1 Inspect / Pack Area	354	0.042	4	0.14	1	4
A2 Code Dating Area	358	0.014	ND	0.035	ND	4
Limit of Detection (LOD)	(ug/filter)	10	1	1	1	2

Wipe Samples	(amount/sample)	(mg)	(ug)	(mg)	(ug)	(ug)
A1 Lehr Belt		ND*	174	6.11	88	51
A2 Lehr Belt		ND*	66	3.56	28	36
Old Lehr Belt		ND*	431	6.30	518	280
Old Lehr Belt		ND*	119	2.42	195	87

ND - not detected above LOD   ND* - not detected at levels significantly greater than average media blank

TABLE V

Microscopic Analysis of Bulk Dust Samples for Asbestos Content

Thomson Consumer Electronics, Inc.
Circleville, Ohio
HETA 89-244
December 14 & 29, 1989

Sample Description	Date Collected	Asbestos Present
Above A2 Stud Machine	12/14/89	chrysotile 20%
I-beam over A2 Line	12/29/89	chrysotile 5%
I-beam over A2 Line	"	chrysotile 20%
I-beam over A2 Line	"	chrysotile 20%
Cooling Air Duct for B1 Line over A2 Top	"	chrysotile 10%
B Line Area Cooling Air Duct over A2 Top	"	chrysotile 15%
Heater Duct over A2 Line	"	chrysotile 1%

Note: Only one bulk sample was collected on 12/14/89 by the NIOSH investigators because of restricted access to areas of concern. The remaining samples were collected on 12/29/89 by both management and union representatives and sent to NIOSH for analysis.

Table VI

Illnesses in 28 Current and Former Employees
Thomson Consumer Electronics
Circleville, Ohio

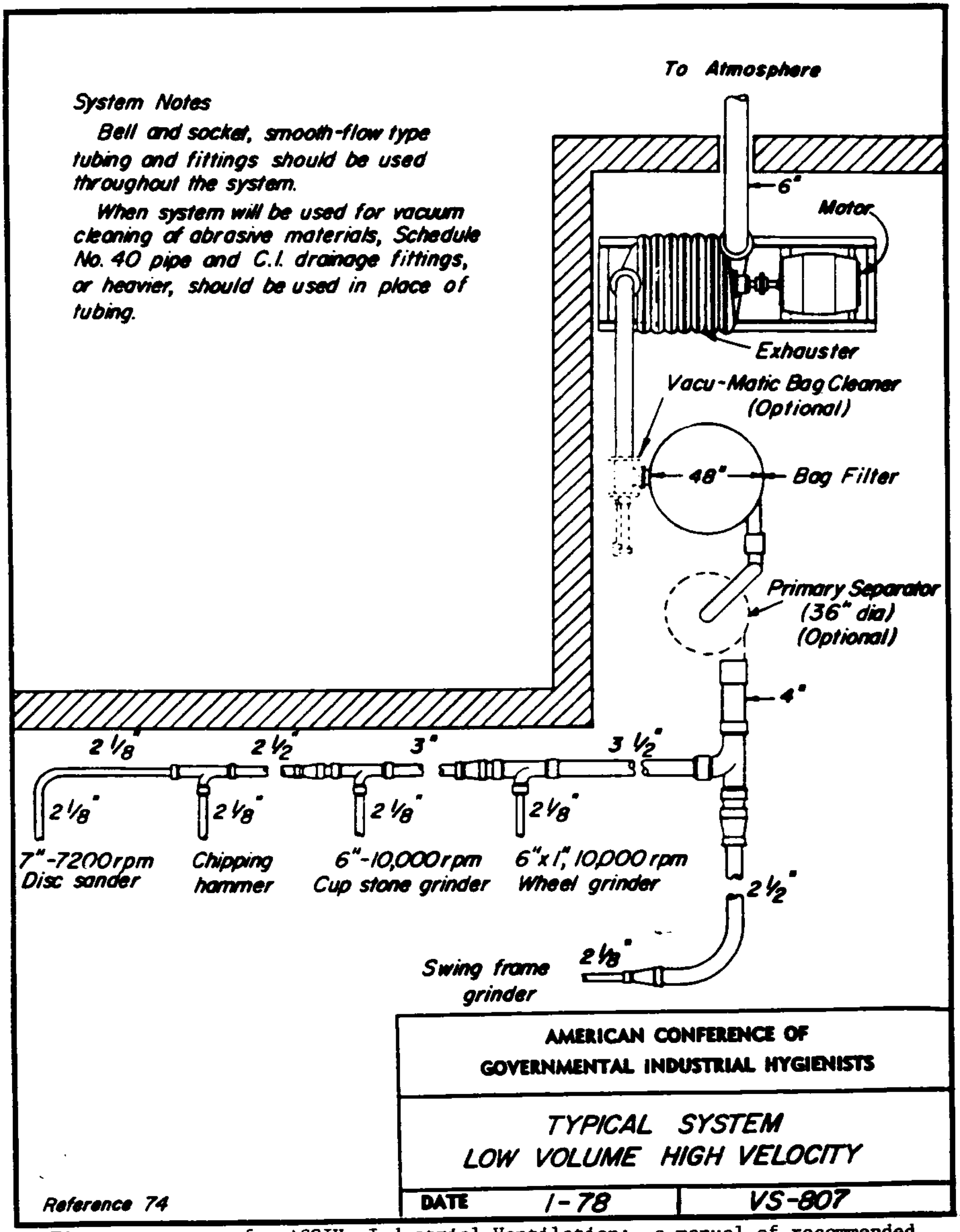
Illness	Number of Employees
Skin cancer	4
Breast cancer	3
Other breast masses	2
Colon cancer	3
Lung cancer	1
Other lung lesions	2
Leukemia	1
Pancreatic cancer	1
Neurofibroma	1
Uterine cancer	1
Other pelvic mass	1
Brain tumor	1
Lupus	1
Phlebitis	1
Peripheral neuropathy	1
Unknown	4

APPENDIX

The following drawings were excerpted from:

American Conference of Governmental Industrial Hygienists. Industrial ventilation: a manual of recommended practice. 20th edition.
Cincinnati, Ohio: American Conference of Governmental Industrial
Hygienists, 1988.

FIGURE 1 -



System Notes

Bell and socket, smooth-flow type tubing and fittings should be used throughout the system.

When system will be used for vacuum cleaning of abrasive materials, Schedule No. 40 pipe and C.I. drainage fittings, or heavier, should be used in place of tubing.

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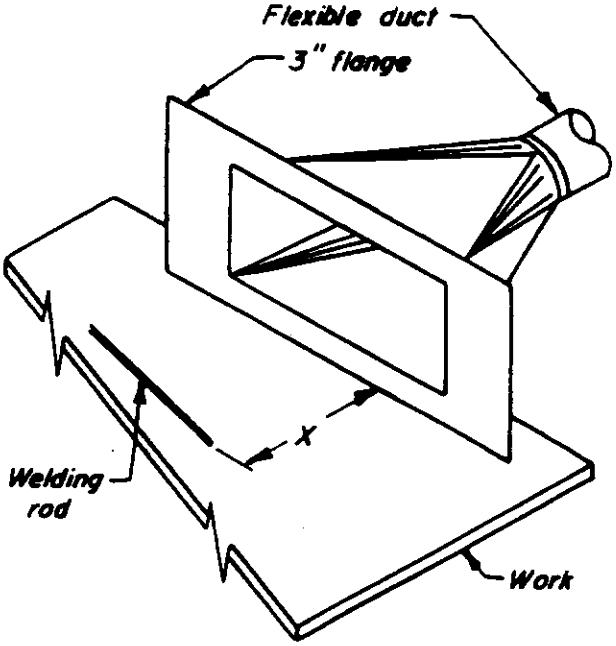
TYPICAL SYSTEM
LOW VOLUME HIGH VELOCITY

DATE	1-78	VS-807

Reference 74

Figure courtesy of: ACGIH, Industrial Ventilation: a manual of recommended practice. 20th edition. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1988.

FIGURE 2



PORTABLE EXHAUST

X, inches	Plain duct cfm	Flange or cone cfm
up to 6	335	250
6 - 9	755	560
9 - 12	1335	1000

Face velocity = 1500 fpm
Duct velocity = 3000 fpm minimum
Plain duct entry loss = 0.93 duct VP
Flange or cone entry loss = 0.25 duct VP

GENERAL VENTILATION, where local exhaust cannot be used:

Rod, diam	cfm/welder
5/32	1000
3/16	1500
1/4	3500
3/8	4500

OR

A. For open areas, where welding fume can rise away from the breathing zone:
cfm required = 800x lb/hour rod used

B. For enclosed areas or positions where fume does not readily escape breathing zone:
cfm required = 1600x lb/hour rod used

For toxic materials higher airflows are necessary and operator may require respiratory protection equipment.

OTHER TYPES OF HOODS

Bench: See VS-416
Booth: For design See VS-415, VS-604
Q=100 cfm/sq ft of face opening
"Granite Cutting" VS-909

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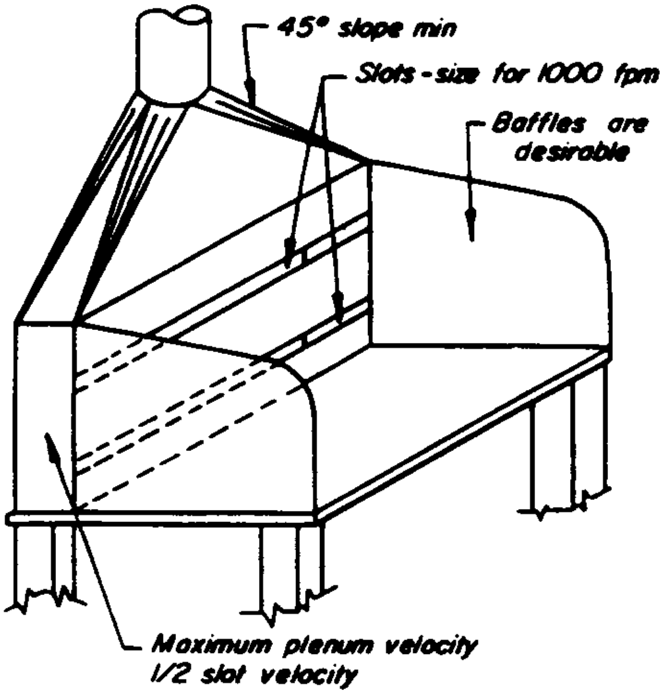
WELDING BENCH

DATE 1-78 | VS-416.1

Figure courtesy of: ACGIH, Industrial Ventilation: a manual of recommended practice. 20th edition. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1988.

FIGURE 3



Q = 350 cfm/lineal ft of hood
Hood length = required working space
Bench width = 24" maximum
Duct velocity = 1000 - 3000 fpm
Entry loss = 1.78 slot VP + 0.25 duct VP

GENERAL VENTILATION, where local exhaust cannot be used:

Rod, diam	cfm/welder*
5/32	1000
3/16	1500
1/4	3500
3/8	4500

OR

A. For open areas, where welding fume can rise away from the breathing zone:
cfm required = 800 x lb/hour rod used

B. For enclosed areas or positions where fume does not readily escape breathing zone:
cfm required = 1600 x lb/hour rod used

*For toxic materials higher airflows are necessary and operator may require respiratory protection equipment.

OTHER TYPES OF HOODS

Local exhaust: See VS-416.1
Booth: For design See VS-415, VS-604
Q=100 cfm/sq ft of face opening

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WELDING BENCH

DATE 1-76 | VS-416

Figure courtesy of: ACGIH, Industrial Ventilation: a manual of recommended practice. 20th edition. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1988.