U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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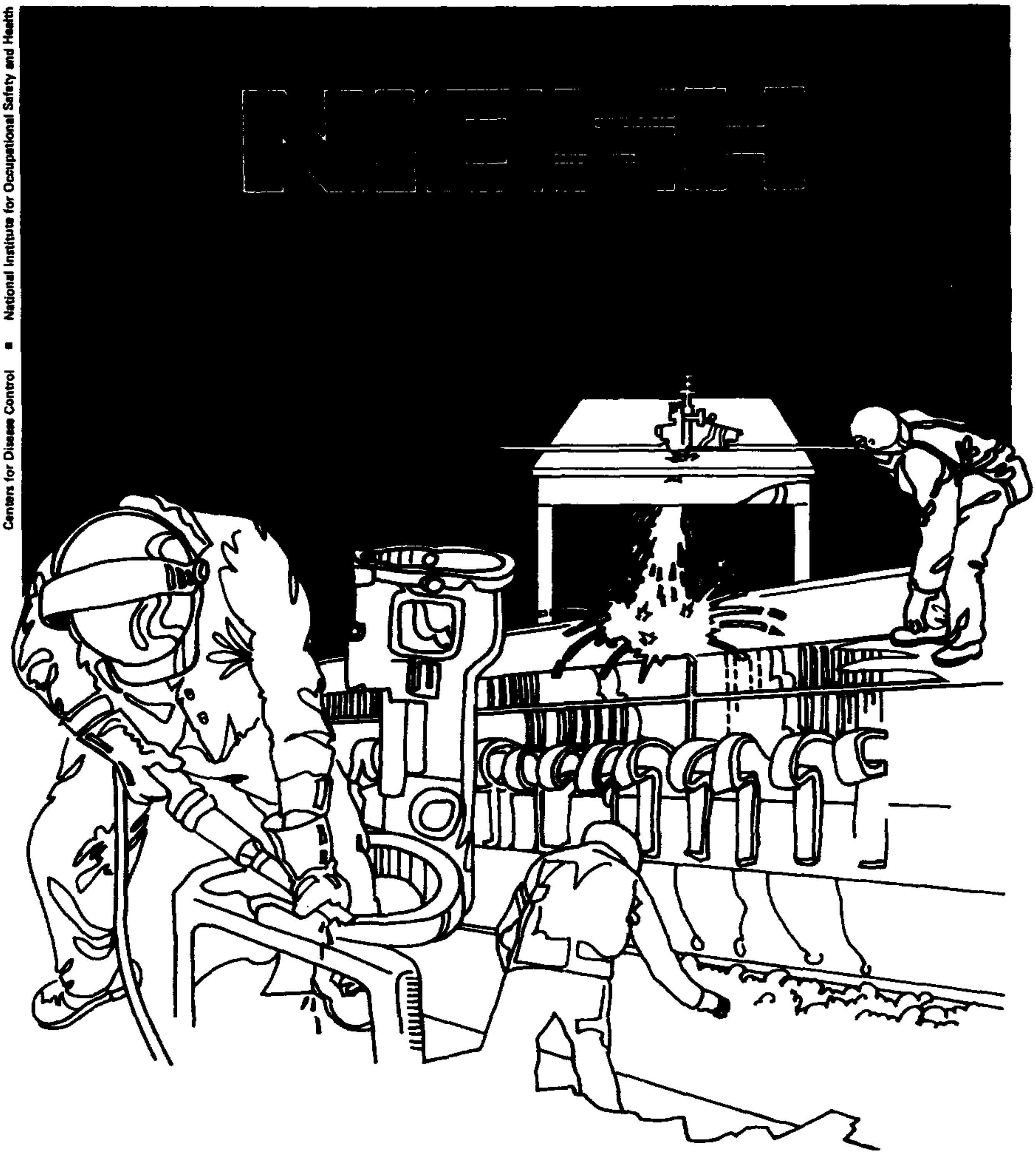

Health Hazard Evaluation Report

HETA 89-137-2005
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA

PREFACE

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

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

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EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA

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I. SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a request, dated February 8, 1989, from the management of Eagle Convex Glass Company, Clarksburg, West Virginia, to evaluate employee exposures and working conditions related to an increase in worker's compensation claims. Potential health effects mentioned in the request included occupational pneumoconiosis, hearing loss, and culmulative trauma disorders (CTD, primarily carpal tunnel syndrome). An initial site visit was made on March 27-29, 1989 and a follow-up survey was conducted on May 16-17, 1989.

Personal breathing-zone (BZ) air samples for acid mist collected in the Etch Department on March 28 and May 17, 1989, measured hydrofluoric acid (HF) concentrations ranging from 0.34 to 3.0 milligrams per cubic meter (mg/m^3), time-weighted averaged (TWA) over the period sampled. Concentrations in general area (GA) air samples ranged from not detectable (ND) to 1.7 mg/m^3, TWA. The NIOSH Recommended Exposure Limit (REL), the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL), and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for HF is 2.5 mg/m^3, TWA.

Bulk samples of two solvents used in the Decorating Department (trade names Aromatic 150 and 1086 Squeegee Oil) were analyzed to identify individual components. The Aromatic 150 contained mostly C_{10} to C_{11} alkyl-substituted benzenes plus naphthalene, characteristic of mineral spirits. Some aromatic compounds, such as trimethylbenzene, methyl ethyl benzene and indan were also present. The 1086 Squeegee Oil contained $C_{10}H_{18}O$ and $C_{10}H_{16}O$ terpene derivatives as the major components, plus some limonene. Personal BZ and GA air samples collected in the Decorating Department were quantitated for total Aromatic 150 and 1086 Squeegee Oil. Concentrations of Aromatic 150 ranged from 1.8 to 11.7 mg/m^3, TWA. Concentrations of 1086 Squeegee Oil ranged from 1.5 to 17.1 mg/m^3. Butyl carbitol, an ingredient in Reducer 419 (a solvent mixture also used in the Decorating Department) was not detected on any of the air samples. NIOSH recommends that occupational exposure to airborne concentrations of mineral spirits, such as Aromatic 150, be controlled so that no employee is exposed to greater than 350 mg/m^3, TWA, for up to a 10-hour work day.

Respirable dust concentrations ranged from 0.08 to 0.20 mg/m^3, TWA. These levels were well below the OSHA PEL for respirable nuisance dust of 5.0 mg/m^3. Quartz and cristobalite (two forms of crystalline silica) were not detected on any of the respirable dust samples collected at Eagle-Convex.

General area air samples were collected in the Decorating Department for a variety of trace minerals and metals. All elements present in detectable quantities from the air samples were below their applicable OSHA PELs, ACGIH TLVs, or NIOSH RELs.

Noise exposures at Eagle Convex were assessed by measuring the sound levels in the Furnace, Decorating, and Mirroring Departments. Personal noise exposures at Eagle Convex ranged from 79 to 92 decibels, A-weighted scale [dB(A)], TWA, in the areas tested. The maximum one-minute noise exposures (representative of higher peak noise exposures) ranged from 90 to 103 dB(A). Eight of 11 noise dosimeter samples exceeded the NIOSH REL for noise of 85 dB(A), TWA.

An ergonomic evaluation found excessive ergonomic stresses in the Decorating, Processing, Mirror, and Polishing Departments. A questionnaire, which was administered to all employees, found that 20-30% of workers in the Processing, Decorating, Mirror, Etching, Maintenance and Packing Departments had symptoms consistent with hand/wrist, shoulder, and neck cumulative trauma disorders.

Based on the data collected during this evaluation, NIOSH investigators concluded that employees in several departments at Eagle Convex Glass Company are exposed to an increased risk of developing a cumulative trauma disorder. Some employee exposures to HF acid mist in the Etch Department exceeded the NIOSH, OSHA and ACGIH exposure criteria for this compound. Noise levels in excess of the NIOSH REL were measured in several departments. Recommendations for providing local exhaust ventilation, altering work practices, making ergonomic changes, and implementing hearing conservation and respiratory protection programs are included in Section VIII of this report.

KEYWORDS: SIC 3231 (Glass Products, Made of Purchased Glass), silica, hydrofluoric acid, sulfuric acid, organic vapors, mineral spirits, pine oil, noise, cumulative trauma disorder, ventilation.

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request, dated February 8, 1989, from the management of Eagle Convex Glass Company, Clarksburg, West Virginia to evaluate employee exposures and working conditions related to an increase in worker's compensation claims. Potential health effects mentioned in the request included occupational pneumoconiosis, hearing loss, and cumulative trauma disorders (CTD), primarily carpal tunnel syndrome. An initial site visit was made on March 27-29, 1989. After reviewing the data collected from the first visit, a follow-up survey was conducted on May 16-17, 1989, to perform additional industrial hygiene measurements.

III. BACKGROUND

The Eagle Convex Glass Company, Clarksburg, West Virginia, has operated since 1937 producing a wide variety of speciality glass products for the automotive, furniture, and major appliance industries. The plant workforce at the time of this evaluation, 171 employees over three shifts, was distributed among the following departments: Receiving, Processing, Decorating, Furnace, Mirror, Etch, Maintenance, Polishing and Shipping. The company does not conduct pre-employment physicals and does not have written programs for hearing conservation or respiratory protection.

Glass sheet stock, ranging in size from 24" x 26" to 36" x 60" (thickness range 1/8" to 5/16", standard thickness 3/16"), is purchased by Eagle Convex from several outside vendors to produce its speciality products. The glass stock is manually cut to the desired shape and sent to the Processing Department where the sharp edges are rounded smooth using large belt sanders (a process termed "swiping"). Depending on the specific item being manufactured, the glass may be: (1) etched, polished, or frosted [using hydrofluoric (HF) and sulfuric (H_2SO_4) acids]; (2) decorated (using silk-screen painting techniques); (3) bent or tempered (heating the glass parts to impart the desired shape or physical characteristic); or (4) mirrored (spraying a layer of silver nitrate on the glass part). Many glass products receive a combination of these treatments.

In the Decorating Department, where the silk screening is performed, most of the pre-mixed glass paints contain various heavy metals such as lead and cadmium. Mineral spirits, used to clean the silk screens, and "pine oil," a mixture of terpene derivatives used as a thinner for the glass paints, are also used. Employee exposures in the Mirror Department include silver (from the silver nitrate used to mirror the glass) and nitric acid (used intermittently to strip the silver coating from products which required reworking). In the Etch Department workers are potentially exposed to HF, H_2SO_4, and nitric acids. In several departments the employees were exposed to noise and at risk for cumulative trauma disorders (CTDs).

IV. EVALUATION DESIGN AND METHODS

A. Industrial Hygiene

1. Acid Gas Sampling

Two personal breathing-zone (BZ) and two general area (GA) air samples were collected for inorganic acids on March 28, 1989, in the Etch Department. In a follow-up survey on May 17, 1989, three personal BZ and two GA air samples were collected for hydrofluoric and sulfuric acids in the same department. All samples were collected on silica gel adsorbent tubes (ORBO 53, manufactured by Supelco) using flow rates ranging from 200 to 500 cubic centimeters per minute (cc/min). Samples were collected for up to an 8-hour work shift.

The air samples were analyzed for chloride, fluoride, nitrate, phosphate, and sulfate ion concentrations by ion chromatography according to NIOSH Method 7903.[1] The "A" and "B" sections (front and rear sections of the adsorbent tube, respectively), and the fiber plug which separates these sections, were separately desorbed. The resulting solutions were filtered through a 0.45 micron filter, and an aliquot was analyzed by ion chromatography. The limits of detection and quantitation (LOD and LOQ, respectively) in the samples collected on March 28 and May 17, 1989 for HF and H_2SO_4 acids, the primary acids used in the Etch Department, are shown in Table 1.

2. Minerals and Metals

Five GA air samples were collected for analysis of trace minerals and metals in the Decorating Department on May 17, 1989. The samples were collected on mixed cellulose ester filters (0.8-micrometer pore size, 37-mm diameter) using a flow rate of 2.5 liters per minute (lpm) for an entire work shift. These samples were analyzed for trace elements and minerals using a simultaneous scanning inductively coupled plasma emission spectrometer controlled by a personal computer via NIOSH Method No. 7300.[1] A list of the metals and minerals which were analyzed are shown in Table 2. The LODs for these substances ranged from 1 to 20 ug/sample.

3. Gravimetric Analysis and Free Silica Determination

Three respirable dust GA air samples and one bulk settled dust sample were collected for determination of free silica content. The respirable dust air samples were collected on pre-weighed polyvinyl chloride filters (5-micrometer pore size, 37-mm diameter) at a flow rate of 1.7 lpm using a cyclone. The particulate weight was determined by gravimetric analysis according to NIOSH Method No. 600, with modifications.[1] These respirable dust samples, along with the bulk sample of settled dust, were subsequently analyzed for quartz and cristobalite by X-ray diffraction following NIOSH Method No. 7500, with modifications.[1]

4. Organic Compounds

Air and bulk samples were collected in the Decorating Department to characterize the various organic compounds present. The full-shift air samples, consisting of eight personal BZ and two GA air samples, were collected on May 17, 1989, using activated charcoal tubes at a flow rate of 100 cc/min. These air samples were submitted for quantitative analysis of organic compounds. The two bulk liquids collected, Aromatic 150 and 1086 Squeegee Oil, were analyzed to identify individual components.

5. Noise

The noise at Eagle Convex was assessed by measuring the sound levels in the Furnace, Decorating, and Mirroring Departments. Both A-weighted sound levels in decibels [dB(A)] and an octave band analysis for the center frequencies of 31.5 Hertz (Hz) through 16 kilohertz (kHz) were obtained in selected areas of the plant.

The noise measurements were made with a GenRad Model 1982 Precision Sound Level Meter. This instrument has octave band measurement capabilities as well as the A, B, C, and flat weighting networks. The sound level meter was calibrated, before and after measurements were made, with a GenRad Model 1986 Omnical Sound Level Calibrator according to the manufacturer's instructions. Additionally, the battery check scale of the sound level meter was examined periodically to insure that the batteries were in the proper operating range.

B. Ergonomic

Seventeen jobs in the Processing, Decorating, Mirror, and Etching

Departments were videotaped. The specific jobs studied are listed in Table 3. The selected jobs either were mentioned on the health hazard evaluation request or were chosen based on apparent risk for cumulative trauma disorders (CTDs) observed during the initial site visit on March 27-29, 1989. All of the selected jobs were subsequently analyzed to determine cycle time, number of movements per cycle, presence of awkward postures, and estimated muscular force requirements.

C. Medical

To determine the prevalence of symptoms of CTDs, all of the workers at Eagle Convex Glass were asked to complete a brief screening questionnaire. Prevalence rates for neck, shoulder, and wrist complaints for each department were compared to the results of the videotape analysis.

For this evaluation a case of CTS was defined as the following:

1. Complaints of pain, repeated feelings of numbness, tingling, or pins and needles sensation in one or both hands,
2. Pain in the hands which causes the person to awaken from sleep, and which interferes with normal activities, and
3. The absence of other medical conditions associated with CTS, including diabetes, gout, thyroid disease, and rheumatoid arthritis.

For this evaluation, a case of shoulder strain was defined as anyone complaining of:

1. Recurrent soreness and pain in either shoulder, where the pain interfered with normal activities, and
2. The absence of other medical conditions.

For this evaluation, a case of neck strain was defined as the following:

1. Recurrent soreness and pain in the neck, where the pain interfered with normal activities, and
2. The absence of other medical conditions.

In order to determine the prevelence of symptoms of cumulative trauma disorders, all of the workers at Eagle Convex Glass were asked to complete a brief screening questionnaire. Prevelence rates for neck, shoulder, and wrist complaints were compared by department to the results of the videotape analysis.

V. EVALUATION CRITERIA

A. Environmental Criteria

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

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

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommended exposure limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH RELs and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA permissible exposure limits (PELs). The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH 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 industry is legally required to meet those levels specified by an OSHA standard.

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

B. Lead

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be 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, resulting in weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.[2,3]

Overt symptoms of lead poisoning in adults generally begin at blood lead levels between 60 and 120 micrograms of lead per deciliter of blood (ug/dl).[2] Neurologic, hematologic, and reproductive effects, however, may be detectable at much lower levels.[4] Recent studies suggest that exposure of the developing fetus to blood lead levels far below these occupational exposure limits is associated with subtle neurologic impairment in early life and that there may not be a safe threshold for this effect.[5,6]

The OSHA PEL for lead in air is 50 ug/m^3 calculated as an 8-hour TWA for daily exposure.[7] This regulation also requires semi-annual blood lead monitoring of employees exposed to 30 ug/m^3 or greater of lead.[7] Employees 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 their average blood lead level is 50 ug/dl or more over a 6 month period.[7]

C. Silica

The crystalline forms of silica can cause severe tissue damage when inhaled. Silicosis is a form of pulmonary fibrosis caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and nonspecific chest illnesses. Silicosis usually occurs after years of exposure, but it may appear in a shorter time if exposure concentrations are very high.

Silicosis is usually diagnosed through chest x-rays, occupational exposure histories, and pulmonary function tests. The manner in which silica affects pulmonary tissue is not fully understood, and theories have been proposed based on the physical shape of the crystals, their solubility, toxicity to macrophages in the lungs, or their crystalline structure. There is evidence that cristobalite and tridymite, which have a different crystalline form from that of quartz, have a greater capacity to produce silicosis.[8]

D. Hydrofluoric Acid

Hydrofluoric acid (HF) is a severe respiratory and skin irritant.[9,10] Absorption of HF can result from both inhalation and skin contact. Above its boiling point HF is a colorless gas which produces transient coughing and choking in moderate concentrations. In severe exposures, following an asymptomatic period of several hours, death may result from pulmonary edema.[10] Hydrofluoric acid solutions in contact with the skin can result in rapid tissue destruction.[9,10] The acid can readily penetrate the skin and deep tissue, attacking the underlying soft tissue and decalcifying the bone. The tissue destruction from HF, unlike most inorganic acids, may be very insidious and extend over several days.[10]

In animal studies, repeated exposures at 17 parts per million (ppm) resulted in damage to the lungs, liver, and kidneys, but at 9 ppm the pathologic changes were insignificant.[9] In a series of human experiments, exposures to HF concentrations as high as 4.7 ppm for up to 6 hours a day were tolerated without severe effects although some redness of the skin and burning and irritation of the upper respiratory tract and mucous membranes did occur at concentrations above 3 ppm.[9]

The NIOSH REL for HF is 2.5 mg/m^3, TWA, with a 15-minute ceiling level of 5 mg/m^3.[11] The ACGIH TLV is 2.5 mg/m^3 for a 15-minute ceiling exposure while the OSHA PEL is 2.5 mg/m^3 for an 8-hour TWA.[12,13] For comparative purposes, a HF concentration of 2.5 mg/m^3 is equivalent to 3 ppm. The ACGIH TLV was selected to minimize the occurrence of fluorosis (accumulation of fluoride by the body).

E. Sulfuric Acid

A dense, oily liquid, sulfuric acid (H_2SO_4) is highly corrosive and a severe irritant to the eyes, skin, and mucous membranes. Sulfuric acid mist may exist in sizes down to a respirable range of below 10 micrometers in diameter.[14] These smaller diameter particles appear to result in the greatest alteration in pulmonary function because of their ability to penetrate deeper into the lung.[10]

The ACGIH TLV, OSHA PEL, and NIOSH REL for sulfuric acid is 1 mg/m^3, TWA.[12,13,14] The ACGIH also recommends a short term exposure limit of 3 mg/m^3. The ACGIH TLV is intended to prevent pulmonary irritation and injury to the teeth from the corrosive action on the dental enamel.

F. Refined Petroleum Solvents

Eye, nose, and throat irritation, dermatitis, and effects on the nervous system have been found in workers exposed to some refined petroleum solvents.[15] Benzene, which has been shown to cause blood dyscrasias in humans, is present in small amounts in many of the refined petroleum solvents. NIOSH has concluded that benzene is leukemogenic.[15]

The solvent "Aromatic 150," used in the Decorating Department to clean the silk-screening equipment consists predominantly of C_9 through C_{11} aromatic hydrocarbons, including naphthalene. NIOSH recommends that occupational exposure to airborne concentrations of refined petroleum solvents such as naphthas, mineral spirits, and rubber solvents be controlled so that no employee is exposed to concentrations greater than 350 mg/m^3, TWA for up to a 10-hour work day.[15] However, when benzene is found to be present in these refined petroleum solvents, effort shall be made to maintain the benzene exposure as low as possible.

G. Noise

Exposure to high levels of noise may cause temporary or permanent hearing loss. The extent of damage depends primarily upon the intensity of the noise and the duration of the exposure. There is abundant epidemiologic and laboratory evidence that protracted noise exposure above 90 dB(A) causes hearing loss in a portion of the exposed population.

The OSHA standard for occupational exposure to noise [29 Code of Federal Regulations (CFR) Part 1910.95] specifies a maximum PEL of 90 dB(A)-slow response for a duration of 8 hours per day.[9] The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship. This means that in order for a person to be exposed to noise levels of 95 dB(A), the amount of time allowed at this exposure level must be cut in half in order to be within OSHA's PEL. Conversely, a person exposed to 85 dB(A) can have twice as much time at this level (16 hours) and still be within the daily PEL. Both NIOSH, in its Criteria for a Recommended Standard, and the ACGIH propose an exposure limit of 85 dB(A) for 8 hours, 5 dB less than the OSHA standard.[16,12] Both of these latter two criteria also use a 5 dB time/intensity trading relationship in calculating exposure limits.

Time-weighted average noise limits as a function of exposure duration are shown as follows:

Duration of Exposure (hrs/day)	Sound Level (dB(A)) NIOSH/ACGIH	OSHA
16	80	85
8	85	90
4	90	95
2	95	100
1	100	105
1/2	105	110
1/4	110	115 *
1/8	115 *	-
		**

*No exposure to continuous or intermittent in excess of 115 dB(A).

**Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

The OSHA regulation has an additional action level (AL) of 85 dB(A) above which an employer shall administer a continuing, effective hearing conservation program.[13] The program must include monitoring, employee notification, observation, audiometric testing, hearing protectors, training, and recordkeeping. All of these stipulations are included in 29 CFR 1910.95, paragraphs (c) through (o).

When workers are exposed to noise levels in excess of the OSHA PEL of 90 dB(A), feasible engineering or administrative controls must be implemented to reduce the workers' exposure levels. Also, a continuing, effective hearing conservation program must also be implemented.

H. Nuisance Particulates

Nuisance particulates can be an irritant to the eyes, nose, throat, and lungs. ACGIH recommends that workers should not be exposed to total nuisance dust concentrations greater than 10 mg/m^3, TWA for up to an 8-hour workshift, 40 hour workweek.[12] The OSHA PELs for respirable and total nuisance dust are 5 mg/m^3 and 15 mg/m^3, respectively.[13]

I. Local Exhaust Ventilation

Effective control of any contaminant-producing process, such as silk-screening or glass etching, is achieved by first eliminating or minimizing all air motion about the process and then capturing the contaminated air by causing it to flow into an exhaust hood. Flow toward the suction opening must be sufficiently high to maintain the necessary capture velocity and to overcome opposing air currents. Countering this air motion necessitates positioning the capture hood as close to the point of contaminant generation as the operation permits. In addition, the hood should be shaped to control the area of contamination and designed to enclose the operation as much as possible.

J. Dilution Ventilation

Dilution ventilation, which is the process of diluting contaminated air with uncontaminated air in a general area, room or building for the purpose of health hazard or nuisance control, can be used for controlling exposures to less toxic materials. The use of dilution ventilation, however, has several limitations. First, the quantity of contaminant generated must not be too great; otherwise, the air volume necessary for dilution will be impractical. Second, employees must be far enough away from contaminant evolution, or evolution of contaminants must be in sufficiently low concentrations, so that the workers will not have an exposure in excess of the permitted or recommended limit. Third, the toxicity of the contaminants must be low and their evolution reasonably uniform throughout the work area.

K. Repetitive Motion

Cumulative trauma disorders (CTDs) of the musculoskeletal system often occur in workers whose jobs require repetitive upper extremity exertion. These disorders include bursitis, ganglionic cysts, musculoskeletal strain, synovitis, tendinitis, tenosynovitis, and/or numerous other specifically described musculoskeletal syndromes, including carpal tunnel syndrome. These disorders affect the nerves, tendons, tendon sheaths, and other synovial tissues of the upper extremities. Studies have shown that these disorders can be precipitated and aggravated by activities associated with repetitive exertion, particularly if completion of the tasks requires significant application of force in an awkward posture.[17-30] The postures most often associated with upper extremity CTDs are wrist extension and flexion, ulnar and radial deviation of the wrist, open-hand pinching, twisting movements of the wrist and elbow, and shoulder abduction. Cumulative trauma disorders are considered, in many cases, to be work-related because these types of postures and movements are required in many jobs. What is common to all of these jobs is repetitive, stereotyped movement of the hand, arm, and wrist, coupled with varying degrees of muscular exertion. The incidence of CTDs in these and other industries has not yet been established, but incidences as high as 44 cases per 100 workers per year have been reported.[31] Non-occupational risk factors include hobbies and recreational activities such as woodworking, tennis, weight lifting, knitting, and sewing. All of these pastimes impose physical demands on the musculotendinous system similar to those of the jobs mentioned above.

Carpal tunnel syndrome (CTS) was recognized as a clinical entity as early as 1895. However, not until 1947 was this median nerve disorder fully described and recognized as a syndrome in the medical literature. The presently accepted clinical presentation of the syndrome includes: (1) pain and parathesias (burning and tingling sensation) in the hand along the distribution of the affected median nerve, (2) precipitation of similar symptoms at night while sleeping, and (3) possible radiation of pain to other portions of the involved arm/hand.[32-36] Carpal tunnel syndrome may be associated with non-occupational factors such as acute trauma, diabetes mellitus, hormonal factors (use of oral contraceptives, pregnancy, and gynecological surgery), rheumatoid arthritis, acromegaly (an uncommon condition arising from hypersecretion of the pituitary growth hormone), wrist shape and size, congenital (at birth) abnormalities, and gout.[37] Since a number of these conditions are unique to women, their risk of CTS may be elevated. While women have been reported to be at high risk for CTS due to occupational factors, very few studies have compared the rate in men and women performing identical jobs. Silverstein et al., found that women and men were at essentially the same risk of CTS if performing identical job activities.[38,39]

There are several factors which may precipitate occupational CTDs. Among these are excessive muscular force, short length of job cycles, and high frequency of movements. One study found that workers performing jobs with force levels of 4 kilograms or more were four times as likely to develop hand/wrist CTDs as those workers whose jobs required muscular exertions of 1 kilogram or less.[40] Job tasks with cycle times lasting 30 seconds or less were found to be associated with an incidence of upper extremity CTDs three times greater than those jobs where the cycle time was greater than 30 seconds.[40] In studies reporting an increased incidence of CTDs, where the number of hand movements were recorded, the range was from 5000 to 50,000 repetitions per day.[21,41-49] The work activities were varied and included cutting poultry, key stroking, hand sanding and filing, and packing tea.

Because of the complexity of repetitive motion patterns, it has been difficult to define a critical frequency factor for defining a CTD risk. Recently, guidelines for using frequency of movement as a method for assigning risk to a repetitive task were developed and applied in a study of a meat processing and packing plant.[50] Low risk was defined as fewer than 10,000 movements per day, medium risk as 10,000 to 20,000 movements per day, and high risk as 20,000 or more movements per day. These criteria for frequency of movement are intended merely as guidelines for judging the relative risk of a hand intensive job task. It is also important to note that other factors associated with the performance of a work activity such as high levels of muscular force exerted, and awkward upper extremity postures, would reduce the number of movements defining each of the above risk categories.

The current strategy for reducing the risk of CTDs for a certain task is to minimize exposure to job factors that are biomechanically stressful, i.e., those with high force, awkward postures, and high repetition rates. This is most effectively achieved through the redesign of work stations, tools, or work methods that were identified through job analysis as risk factors for CTDs.

VI. RESULTS

A. Environmental

1. Hydrofluoric Acid

Two personal BZ samples collected in the Etch Department during the initial visit to Eagle Convex on March 28, 1989, measured HF in concentrations ranging from 1.3 to 3.0 mg/m^3, TWA, over the period sampled. Two GA air samples collected at the same time measured HF levels of 0.03 and 1.7 mg/m^3. The NIOSH REL, OSHA PEL and ACGIH TLV for HF is 2.5 mg/m^3, TWA.

Based on these results, additional air sampling was conducted for inorganic acids in the Etch Department on the follow-up survey conducted on May 17, 1989. Concentrations of HF in personal BZ air samples ranged from 0.34 to 0.67 mg/m^3. Hydrofluoric acid was not detected in GA air samples collected near the quality control station and immediately outside the Etch Department. Results of acid gas air sampling from both the initial and follow-up surveys are presented in Table 1.

2. Organic Compounds

a. Bulk Samples

The two bulk liquids collected from the Decorating Department (Aromatic 150 and 1086 Squeegee Oil) were analyzed by GS-MS to identify individual components. The Aromatic 150 bulk sample contained mostly C_{10} to C_{11} alkyl-substituted benzenes (for example, diethylbenzenes, dimethylbenzenes, methyl butyl benzenes, etc.), plus naphthalene. Some aromatic compounds, such as trimethylbenzene, methyl ethyl benzene, and indan were also present. The 1086 Squeegee Oil contained $C_{10}H_{18}O$ and $C_{10}H_{16}O$ terpene derivatives as the major components, plus some limonene. The reconstructed chromatograms for Aromatic 150 and 1086 Squeegee Oil are shown in Figures 1 and 2, respectively.

b. Air Samples

Personal BZ and GA air samples were quantitated for total Aromatic 150, 1086 Squeegee Oil, and butyl carbitol, an ingredient in Reducer 419 (a solvent mixture used in the Decorating Department). No butyl carbitol was detected in any of the air samples. The LOD for all three analytes was 5 ug/sample; the LOQ was 15 ug/sample. The results of these analyses (field blank corrected) are shown in Table 3.

3. Noise

The survey results from the noise dosimetry are given in Table 4. The table shows the areas which were sampled, the elapsed time of the sampling period (in hours), the 8-hour TWA Level (L_{OSHA}), calculated according to current OSHA regulations, and the corresponding percentage of the daily noise dose. The remaining column, "Max Period Level", is the highest one-minute noise sample which was stored in the dosimeter during the sampling period.

Personal noise exposures at Eagle Convex ranged from 79 to 92 dB(A) TWA in the areas tested. The maximum one-minute noise exposures (representative of peak noise exposures) ranged from 90 to 103 dB(A). Eight of 11 noise dosimeter samples were in excess of the NIOSH REL for noise of 85 dB(A), TWA. The individual dosimeter readouts are graphically presented in Figures 3 through 6.

Sound level meter samples collected in the Furnace, Decorating, Processing, and Mirror Departments are shown in Table 5. This table contains the overall dB(A) level and the individual octave band levels from 63 to 8000 Hz at each location. Overall levels ranged from 81 to 103 dB(A) during the monitoring period. Higher frequency noise (1000 Hz and above) predominated during the operation of the "lazer jet", a high pressure water and sand slurry glass cutting machine. Lower frequencies (500 Hz and below) predominated at locations near the #9 furnace, the #5 cleaning machine in the Processing Department, and at the "Roper" machine located in the Mirror Department.

4. Respirable Dust and Crystalline Silica

Respirable dust concentrations ranged from 0.08 to 0.20 mg/m^3, TWA over the period sampled. These levels are far below the OSHA PEL for respirable nuisance dust of 5.0 mg/m^3. Quartz and cristobalite (two forms of crystalline silica) were not detected on any of the respirable dust samples collected from Eagle-Convex.

5. Minerals and Metals

Three GA air samples were collected in the Decorating Department near potential exposure sources (adjacent to two automatic silk-screening operations and in the paint pigment storage and mixing area). A list of the minerals and metals for which the samples were analyzed, and their respective LOD's and LOQ's, are shown in Table 2. All substances were below their applicable LOD except for calcium, iron, magnesium, lead, and sodium which were found in concentrations above the LOD but far below their applicable OSHA PELs, ACGIH TLVs, or NIOSH RELs.

B. Repetitive Motion Assessment

The job analysis summary for each of the jobs studied in detail is contained in Table 6. The most noteworthy figures in this table are the total number of movements per day, the catalog of hazardous postures, and the subjectively assigned force assessment. The accuracy of the movements per day estimate depends on how well the 10-15 cycles of each job that were analyzed represent the actual rate at which jobs are routinely performed. Among the 17 jobs rated, the frequency of movements ranged from approximately 5200 to 40,000 movements per day, with 10 jobs (59%) rated at more than 10,000 movements per day.

C. Medical

There were 170 hourly workers and 37 salaried workers in the plant on the day of the survey. Of those, 175 completed the questionnaire for a response rate of 85%. The results of the medical survey are summarized in Table 7. Between 25 and 30 percent of the workers currently employed in a number of departments had complaints consistent with carpal tunnel syndrome and in most of these same departments over 25% also had shoulder and neck complaints. The departments with the highest prevalence of complaints included Decorating, Mirror, Processing, Etching, Maintenance, and Packing. Administration workers had a high prevelance of neck and shoulder problems but not hand problems. Decorating, Processing, and Mirror Departments were identified by the ergonomic analysis as requiring high repetition and/or force. Etching was found to have only moderate repetition and Maintenance Packing and Administration were not evaluated by the ergonomists.

VII. DISCUSSION

A. Environmental

1. Decorating Department

Based on the uniform concentrations measured during this survey, the organic vapors released from the paints and solvents are well dispersed and poorly controlled at their point of generation. The lack of local exhaust ventilation at the silk screening work stations contributes to this problem. While the levels of organic vapors from the solvents used in this department are low in comparison to the NIOSH REL for refined petroleum distillates, the solvent concentrations do exceed their respective odor thresholds, presenting a potential nuisance problem for the employees in the Decorating Department.

General exhaust ventilation for the approximately 10,000 ft^2 Decorating Department is provided through a combination of roof and wall mounted exhaust fans. A mechanical heating and air-conditioning system mixes fresh air with the recirculated air from the Decorating Department and returns it, through ducts, to 14 locations scattered throughout the department. At each location an open duct (without a diffuser) terminates approximately 10 feet off the floor, near either an automatic or manual silk-screening work station. No information could be provided by the company on the specifications of this heating and cooling system. This system was intended primarily for thermal comfort of the Decorating Department workers (cooling in the summer, heating in the winter).

Organic vapors are released during the silk-screening process and when the equipment is periodically cleaned. Several other operations in the department are also potential contributors to the odor problem. One is the natural gas-heated drying oven located at the west end of the department. Although locally exhausted via a roof fan (again, of unknown size), visual checks using ventilation smoke tubes on May 17, 1989, revealed that the exhaust system was incapable of maintaining this oven under negative pressure, a condition which would allow air to flow from the Decorating Department into the oven when the doors are opened to add or remove glassware. Instead, the oven was under positive pressure. This means that air, containing organic vapors released from the painted glass parts, flowed into the Decorating Department, further contributing to the nuisance odor.

2. Etch Department

As previously mentioned, BZ air concentrations of HF ranged from 0.34 to 3.0 mg/m^3, TWA. These results suggest that at least a portion of the personal exposures to HF vary considerably and concentrations may periodically exceed the NIOSH, OSHA, and ACGIH exposure criteria for this compound of 2.5 mg/m^3.

Ventilation along the two identical etch lines is provided by four roof mounted exhaust fans (two fans per line, each of undetermined age or capacity) connected to a crude, but somewhat effective, slot ventilation system. A visual evaluation of the ventilation system indicated good capture of airborne contaminants when cross drafts were minimal. However, floor-mounted pedestal fans were used in this area, disrupting the efficacy of the slot ventilation.

Smoke tubes indicated that the Etch Department was under negative pressure in relation to the surrounding areas. While this situation is advantageous toward restricting airborne acid mists to within the Etch Department, NIOSH investigators observed significant turbulance caused by the air rushing into the Etch Department from adjacent areas of the plant. This influx of air disrupted the ventilation system along both etching lines, especially at the HF polishing tanks which contain the highest concentration of HF and sulfuric acid.

3. Acid Cleaning of Defective Mirrors

Defective mirrors, due to imperfections arising during silver application or from chips in the glass, are recycled whenever possible by manually stripping the silver coating using concentrated (42%) nitric acid. Although this intermittent operation was not performed during either the initial or follow-up visits, a NIOSH investigator interviewed an employee who had worked at the stripping operation on several occasions. Based on information gathered in this interview, along with observations of the "acid room" where the manual cleaning is performed, potentially serious safety and health deficiencies, which are discussed below, exist in this operation.

The small (approximately 100 ft^2) "acid room" where the mirror cleaning is conducted has minimal ventilation and poor lighting. Large, fragile glass pieces are stripped in the center of the room without the benefit of local exhaust ventilation. Smaller glass parts may be stripped near a crude slot ventilation system located in one corner of the room. The employee interviewed indicated that some personal protective equipment, such as gloves, apron, and a face shield, was used but respiratory equipment was not worn during the cleaning operation.

B. Ergonomic

Two jobs, both performed in the Processing Department, which comprised the highest combinations of force and repetition were "swiping", a manual procedure where the sharp edges on the cut glass stock are dulled, and glass polishing. Swiping, whether it involved large glass, small glass, or mirrors, presents a high risk for development of upper extremity CTDs. In all cases, the force exerted was judged to be high, and estimated movements per day ranged from about 19,300 to 26,400. The only exception was the one observed swiping job using a "swiping table" to hold the glass. The use of a support table to maneuver the glass stock reduced the movements per work day to an estimated 5500, lessened the force required to perform the job, and eliminated awkward postures.

Glass polishing jobs require varying amounts of force and repetition. In the case of polishing mirrors, many small circular movements are performed. This job would require almost 40,000 movements in an eight-hour period, if performed for an entire shift. Large pieces of glass, such as television screens and furniture glass, require the worker to hold them against a buffing wheel to remove imperfections. In the case of furniture glass, many of the imperfections are due to flaws in the molds that are used to shape the glass. For both television and furniture glass, the movements recorded were mainly large swinging movements involving the shoulder and body as the piece of glass was polished. The force rating of "high" for these polishing jobs pertains to the static holding of the glass weighing 25-30 pounds while buffing. These jobs seem to present a greater hazard to the neck, shoulder, and back than to the hand/wrist. The main hand/wrist movements are performed when the glass is set down and finish polished with a soft rag. These are typically very low force movements.

In addition to swiping and polishing, glass decorating jobs, using either automatic ("Type A" decorators) or manual ("Type B" decorators) silk screening equipment were studied. The "A" and "B" decorator jobs impose similar demands on the worker in terms of repetition and force. The major difference is the high peak force required for the "B" decorators to spread the paint on the glass. This portion of the job is performed by a machine in the "A" decorating area. In each "A" and "B" decorator category two jobs were performed.

In the first "A" decorator job, the worker removed stove glass from a rack, placed it on the machine, and activated the painting mechanism. The piece was then moved automatically to the next work station by a conveyor. The second job performed by "A" decorators followed the same procedures except after the piece was painted the worker removed the glass from the machine, inspected it, and placed it on a revolving rack to the right. Because of the time involved in performing these extra tasks, the worker processes a fewer number of pieces each hour when compared to the first "A" decorator job.

The "B" decorator jobs were almost identical to "A" decorators except that: (1) the worker obtained unpainted glass from a stationary rack and placed painted parts on the revolving conveyor; or (2) the worker obtained painted glass from the revolving conveyor, applied a second coat of paint, and then placed finished parts on a stationary rack. In addition, the worker in this second job had to make two "passes" with the painting tool to complete the operation.

The remaining jobs studied (inspecting stove glass, inspecting/packing etched glass, and washing mirrors) involved moderate repetition, low or medium force, and no excessive postural demands. These jobs seemed to contain no elements presenting a notable risk to the worker.

C. Noise

1. Furnace Department

Only one of the three furnace operators monitored exceeded the NIOSH REL for noise of 85 dB(A) for an 8-hour TWA. It should be emphasized, however, that noise levels measured with the sound level meter throughout the Furnace Department regularly exceeded 85 dB(A), making it possible for employees in this department to be potentially overexposed to noise on any given day. Two factors influencing the noise level in this area are the number of furnaces operating and the type of glass (size and thickness) receiving heat treatment.

On the day of the noise dosimetry survey, only two furnaces were in operation. Furnace #15 was not one of the two furnaces operating. Based on the noise levels measured in the Furnace Department hearing protection is recommended until such time as feasible engineering controls are installed which could reduce noise levels to below 85 dB(A).

2. Mirror Department

Noise dosimetry results from this area suggest that the "Roper" machine, a device used to remove various coatings which have been applied to glass parts, was the primary noise contributor in this department.

3. Decorating Department

Full-shift noise levels from this department as determined by personal, dosimetry sampling, were above the NIOSH REL of 85 dB(A), with maximum one-minute exposures ranging from 97 to 98 dB(A). No employees were observed wearing hearing protection in this department during this evaluation.

4. Processing Department

The processing department encompasses a variety of speciality jobs such as "swiping", polishing, and drilling, and the noise levels vary according to the particular activity. Noise levels were highest along the glass drilling line and at the "swiping" operations. An operation which did not to exceed the NIOSH REL for noise was manual glass cutting.

An octave band analysis of the "lazer jet" glass cutting operation identified noise levels in excess of 100 dB(A) at the operator's work zone (Figure 6). The noise was predominately high frequency (above 1000 Hz). Based on these levels, the lazer jet was a major noise contributor to the surrounding work areas. Recommendations to enclose the lazer jet drilling operation, or to install barriers separating this machine from the workers located along the adjacent glass drilling line, are included in Section VIII.

VIII. RECOMMENDATIONS

1. Air should not be recirculated in the Decorating Department. The current ventilation system mixes contaminated air with fresh air in the unit located outside the building. The HVAC system serving this area should be redesigned to eliminate air recirculation.

2. Some improvement in the air quality in the Decorating Department will be achieved by eliminating the recirculation of contaminated air. The following recommendations, if implemented, should further reduce the overall concentration of organic vapors in this work area:

   a. All cleaning of silk screening equipment using solvents such as Aromatic 150 should be consolidated to a ventilated booth or separately ventilated room. Currently the employees clean their screens and paint applicators at their work station without the benefit of local exhaust ventilation. This practice contributes unnecessarily to the overall concentration of volatile organics in the room air. In addition, all containers of solvents and paint should be kept tightly closed while not being used.

b. The exhaust capacity of the ventilation system supplying the "walk-in" drying oven should be increased to maintain the enclosure under a slight negative pressure. The proper fan selection will be influenced by the operating temperature of the oven.

c. Ideally, providing local exhaust ventilation system for each silk-screening work station would reduce solvent emissions. However, considering the low air concentrations of solvents measured in the department, it may be appropriate to delay planning of a local exhaust ventilation system until the benefits obtained from the other recommended changes are evaluated.

3. Employees should not be permitted to consume food or beverages in the Decorating Department or in other areas of the plant where toxic materials are in use. Many of the glass paints used in this area contained high concentrations of lead and cadmium in their pigments. For example, some paint pigments contained as much as 50% by weight of lead. Considering the toxicity of these materials, the current practice of cleaning and storing coffee cups in the Decorating Department should be discontinued.

4. Back-up alarms should be installed on all fork trucks and other moving pieces of equipment used at Eagle Convex Glass.

5. Additional evaluation of the mirror "stripping" operation should be conducted, including personal air sampling for nitric acid mist. Based on observations of the "acid room" during this survey, improvements should also be made in ventilation, lighting, general housekeeping, and personal protective equipment.

   a. Local exhaust ventilation may be necessary at the point where the acid stripping is performed. This ventilation system should be flexible enough to accommodate the cleaning of both large and small mirrors and other glass parts. An example of a backdraft ventilated booth suitable for cleaning the mirrored glass parts is shown in Figure 7.

   b. The current lighting system (mercury vapor lamps) used in the acid room required a considerable "warm-up" period (over 10 minutes when checked during this evaluation) before maximum illumination was reached. Work practices should be reviewed to assure that work is not begun in this room until full illumination is reached.

c. Unused materials, shipping boxes, excess acid, and partially cleaned mirrors were stored in the acid room, creating a cluttered work space. Based on these observations, the general housekeeping in the acid room should be improved.

d. Personal protective equipment should be worn when handling concentrated nitric acid. Protective gloves made of neoprene or polyethylene/ethylene vinyl alcohol laminate (EVAL) offer good resistance to this acid. Protective aprons, made of either neoprene or polyethylene, should also be worn. Although no air samples for acid mists were collected during this evaluation, as a minimum (until air monitoring results demostrate that personal exposures to nitric acid mist are not excessive) an approved half-mask air purifying respirator, equipped with acid mist cartridges, should be worn by the operator. The operator should also wear a protective splash shield.

5. Since some workers at Eagle Convex are provided with respirators, there should be a respirator program consistent with the guidelines found in DHHS (NIOSH) Publication No. 87-116, "A Guide to Industrial Respiratory Protection," and the requirements of the General Industry Occupational Safety and Health Standards (29 Code of Federal Regulations Part 1910.134). Standard operating procedures should be developed concerning respirator selection, use, maintenance, respirator fit-testing, cleaning and storage.

6. A hearing conservation program should be implemented at Eagle Convex Glass which meets the requirements set forth in the OSHA noise regulation, 29 Code of Federal Regulations Part 1910.95.

7. The following recommendations are offered to reduce noise levels in various departments at Eagle Convex.

   a. Air exhaust mufflers are recommended to quiet impulsive air exhaust discharges which were observed at the #15 furnace. These discharges were associated with the table which moves the glass pieces through the furnace. These mufflers, generally small and inexpensive, are capable of reducing air discharge noise by 10 to 20 decibels. In addition, all unnecessary air leaks from equipment should be eliminated.

   b. Sound isolation booths should be constructed in the Furnace department for the quality assurance inspectors to work in while the furnaces operate. These booths will reduce the noise exposure to the inspector as well as reduce the heat levels to which they are exposed. The heat is controlled through the HVAC necessary in all sound isolation enclosures.

c. A partial enclosure or barrier, constructed of sound-absorbent material, should be constructed at the "lazer jet" glass drilling operation. Since the noise generated from this operation is predominately high frequency, an acoustical barrier separating the "lazer jet" from the adjacent glass drilling line should result in reduced noise exposure for these employees. To be effective, the partial enclosure must enclose as much of the radiating sound source (lazer jet) as possible. In addition, the maximum possible application of sound absorption material on all interior surfaces (the side facing the sound source) should be used. This type of approach could also be used in the Decorating Department in the tank cleaning operation and in the Mirror Department for the Roper machine.

d. The homemade ventilation hood in the Decorating Department is a major noise source. This enclosure should be replaced with an enclosure/booth manufactured by someone who has knowledge in acoustics and ventilation.

e. Necessary (but noisy) sources should be operated at times that results in noise exposure for the fewest number of workers. Examples here would be operating the "lazer jet" drilling machine or furnace #15 (when thin glass is being tempered) during the second shift.

f. The ventilation system in the Etching Department generates a great deal of low frequency noise (Figure 6). A consultation with an acoustical/ventilation engineer should help to reduce this source of noise.

8. The following ergonomic changes should be made.

a. Reduce the reach required to load unpainted glass onto the conveyor of the first "A" decorating machine. This can be achieved by placing the silk screen closer to the edge of the machine.

b. Provide an automatic painting mechanism for all "B" decorating work stations. The manual loading and unloading of glass need not be eliminated, but the method of spreading the paint should be mechanized. This modification is most needed on large glass jobs, particularly on those operations where large areas of the glass are painted.

c. In both the "A" and "B" areas, job operations should be sequenced so that a given side of the glass is completely painted before painting operations on the other side of the glass are scheduled. This manufacturing practice would minimize the need to flip the glass to properly orient finished pieces on the revolving rack.

d. Automate all swiping jobs or modify all swiping jobs to include a swiping table. The current program of rotating workers through jobs within the processing department should be continued in the interim, but emphasis should be placed on eliminating the manual swiping of glass (including mirrors) as soon as possible.

e. Automate the polishing of mirrors or modify the process currently in use. As noted in the job analysis, this job requires an unacceptably high frequency of movement. Rotating workers through the various jobs in the Mirror department is a method of minimizing the total movements per day of the polishers, and should be continued. However, an alternative to the manual polishing of mirrors should be sought. A polishing work station equipped with a fixture to hold the mirrors and an overhead, suspended buffing tool to polish the mirrors, is an alternative that could be considered.

f. Eliminate the need to hold the heavy glass while buffing and polishing. This can be accomplished by providing a boom mechanism or other method of suspending the glass above the buffing wheels so that the worker merely has to move the glass laterally to reach the various areas to be buffed. A suspended, counterbalanced frame to which the glass can be mounted is one way of achieving this recommendation. Alternatively, the glass can be mounted on an easel, and a buffing tool suspended from overhead could be used to finish and polish the glass.

g. When polishing furniture glass, improve the quality control of bent glass to minimize the number of imperfections that must be removed. This would require the replacement of flawed molds, but may be an expenditure worth considering if problems associated with finishing furniture glass continue. If the amount of buffing and polishing required is significantly reduced, further modification of this job may not be required.

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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. Eagle Convex Glass Company, Clarksburg, West Virginia
2. American Flint Glass Workers Union, International Office, Martinsburg, West Virginia
3. American Flint Glass Workers Union, Local 567, Clarksburg, West Virginia
4. NIOSH, Cincinnati Region
5. OSHA, Region V

TABLE 1
EXPOSURE TO HYDROFLUORIC AND SULFURIC ACIDS
ETCH DEPARTMENT
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE VOLUME[a]	SAMPLE LOCATION	CONCENTRATION[b] HF	H_2SO_4
Initial Site Visit, 3/28/89					
GB-10	BZ	145	ETCH GROUP LEADER	3.0	0.03
GB-11	GA	150	AT QA STATION	0.03	0.02
GB-12	BZ	142	ETCH GROUP LEADER	1.3	0.02
GB-13	GA	146	NEAR HF GLOSS TANK	1.7	0.02
Limit of Detection (ug acid per sample)				0.7	2.1
Limit of Quantitation (ug acid per sample)				0.5	1.5
Follow-up Site Visit, 5/17/89					
HF-1	BZ	68	ETCH GROUP LEADER	0.56	ND
HF-6	BZ	26	" " "	0.67	ND
HF-2	BZ	62	ETCH GROUP LEADER	0.56	ND
HF-7	BZ	26	" " "	0.65	ND
HF-3	BZ	62	MATERIAL HANDLER	0.34	ND
HF-8	BZ	28	" "	0.62	ND
HF-4	GA	62	AT QA STATION	ND	ND
HF-9	GA	29	" " "	ND	ND
HF-5	GA	66	OUTSIDE ETCH DEPT.	ND	ND
HF-10	GA	31	" " "	ND	ND
Limit of Detection (ug acid per sample)				2.0	3.8
Limit of Quantitation (ug acid per sample)				4.0	13.0

TABLE 1, continued
EXPOSURE TO HYDROFLUORIC AND SULFURIC ACIDS
ETCH DEPARTMENT
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

Evaluation Criteria:	HF	H_2SO_4
NIOSH	2.5[c], 5.0[d]	1.0[c]
OSHA	2.5[c]	1.0[c]
ACGIH	2.5[d]	1.0[c], 3.0[d]

GA = general area air sample
BZ = breathing-zone air sample
ND = not detectable
a Sample volume is expressed in liters.
b Concentration expressed in milligrams per cubic meter, TWA.
c Eight-hour time-weighted average exposure level.
d 15-minute ceiling exposure level.

TABLE 2
LIMITS OF DETECTION
GENERAL AREA AIR SAMPLES FOR MINERALS AND METALS
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

Analyte	Limit of Detection, microgram per sample
Aluminum	10
Arsenic	5
Barium	1
Beryllium	1
Calcium*	5
Cadmium	1
Cobalt	1
Chromium	1
Copper	1
Iron*	1
Lithium	5
Magnesium*	2
Manganese	1
Molybdenum	1
Nickel	1
Lead*	2
Phorphorus	10
Platinum	10
Selenium	10
Silver	2
Sodium*	20
Tin	10
Tellurium	10
Thallium	10
Titanium	10
Tungsten	10
Vanadium	1
Yttrium	1
Zinc	2
Zirconium	10

* These substances were present in amounts exceeding their respective LOD's but below NIOSH, ACGIH, and OSHA exposure criteria.

TABLE 3
PERSONAL AND GENERAL AREA AIR SAMPLES
FOR ORGANIC COMPOUNDS
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE VOLUME	SAMPLE LOCATION & TYPE OF OPERATION	CONCENTRATION AROMATIC 150	1086 OIL
CT-1	BZ	32.2	Table 4, Manual	6.2	5.6
CT-11	BZ	14.5	" "	4.8	7.1
CT-2	BZ	24.8	Machine 8, Auto	2.8	3.8
CT-12	BZ	15.2	" "	3.1	4.9
CT-3	BZ	32.3	Machine 1, Auto	2.1	3.7
CT-13	BZ	16.3	" "	11.7	17.1
CT-4	BZ	28.9	Machine 6, Auto	7.5	11.0
CT-14	BZ	9.5	" "	7.7	9.9
CT-5	BZ	31.8	Table 15, Manual	1.8	3.0
CT-15	BZ	13.5	" "	7.8	15.7
CT-6	GA	30.3	Wash Tank Area	2.4	7.7
CT-16	GA	15.2	" " "	6.5	9.1
CT-7	GA	30.9	Paint Mix Area	3.4	8.9
CT-17	GA	15.6	" " "	3.8	13.6
CT-8	BZ	24.4	Machine 3, Auto	3.9	6.0
CT-18	BZ	8.4	" "	2.9	7.4
CT-9	BZ	30.0	"Heavy" Decorating	3.0	7.9
CT-19	BZ	14.8	Machine	3.9	13.9
CT-10	BZ	31.4	Tables 1 and 12,	5.4	6.2
CT-20	BZ	15.8	Manual	7.3	1.5
Limit of Detection (per sample)				0.005	0.005
Limit of Quantitation (per sample)				0.015	0.015

BZ = Personal air sample collected in the breathing-zone of the employee.
GA = General area air sample.
Concentrations of Aromatic 150 and 1086 Squeegee Oil are expressed in milligrams per cubic meter. Sample results have been field blank corrected.

TABLE 4
PERSONAL DOSIMETER DATA
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

Job Sampled	Elapsed Sampling Time (hours)	$L_{(OSHA)}$	Maximum Period Level[a]	Percent Dose[b]
#9 Furnace Operator	8:00	82.5 dBA	90 dBA	35%
#9 Furnace Operator	8:00	84.4 dBA	94 dBA	45%
#10 Furnace Operator	8:00	86.8 dBA*	98 dBA	65%
Decorating: Tank Cleaning	8:00	91.1 dBA*	98 dBA	115%
Decorating: Silk Screening	8:00	86.0 dBA*	97 dBA	58%
Processing: Drill Station	8:00	92.3 dBA*	103 dBA	140%
Processing: Stripper Oper.	5:00	86.8 dBA*	96 dBA	65%
Processing: Cutter	8:00	79.2 dBA	90 dBA	25%
Processing: #5 Machine	8:00	88.2 dBA*	97 dBA	80%
Processing: Swipe Line	8:00	87.0 dBA*	96 dBA	65%
Mirroring: Roper Machine	6:00	86.0 dBA*	95 dBA	58%
Exposure Criteria:				
NIOSH[c]		85.0 dBA		
OSHA		90.0 dBA		

* Value in excess of the NIOSH REL of 85 dBA.

a Maximum period level is the highest one-minute noise sample which was stored in the dosimeter.

b Percent dose is in reference to OSHA's PEL for noise with 100% dose representing a time-weighted average of 90 dBA.

c The NIOSH REL is 85 dBA-slow for an 8-hour time-weighted average.

TABLE 5
OCTAVE BAND ANALYSES
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

May 17, 1989

AREA SAMPLED	OVERALL LEVEL (dBA)	63	125	250	500	1000	2000	4000	8000
		OCTAVE BAND CENTER FREQUENCIES (Hz)*							
Lazer Jet, Location 1	103	76	78	76	81	89	92	97	100
Lazer Jet, Location 2	101	75	77	77	82	86	92	95	96
Roper Machine, Location 1	87	78	86	77	80	81	81	79	76
Roper Machine, Location 2	90	82	89	80	83	85	85	81	80
#5 Cleaning Machine	88	84	84	80	81	81	82	82	78
#9 Furnace, Location 1	81	81	80	79	80	76	76	72	68
#9 Furnace, Location 2	86	80	81	78	82	82	83	74	67
#9 Furnace, Location 3	88	89	87	80	85	84	78	78	72

*The individual octave bands are expressed in unweighted sound pressure levels (re. 20 uPa).

Comments:

Lazer Jet Locations:
- #1 Readings taken between the two lazer jets. One jet was not cutting glass at time of this survey.
- #2 Readings taken between the operating lazer jet and the outside wall.

Roper Machine Locations:
- #1 Approximate location of the employee when operating this glass cleaning machine.
- #2 Readings taken adjacent to the high noise area of the Roper Machine (blowing air). No employees worked in this immediate vicinity for extended periods of time.

#9 Furnace Locations:
- #1 Area where operator spent majority of time.
- #2 Readings taken between this furnace and the outside wall, next to turbine fan.
- #3 Readings taken adjacent to air slots.

TABLE 6
JOB ANALYSIS RESULTS
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

Job Name	Cycle Time[a]	Pieces per Hour	Movements per piece	Movements per day	Awkward Postures	Estimated Force
Inspect Stove Glass	18.6	193	6	9290	None	Low
Polishing Mirrors	75	48	104	39936	Trunk flexion	Medium
"B" Decorator (Big Glass)	20	180	7	10080	Pinch Left and right extension	Medium to High Force
"B" Decorator (2nd Paint operation)	22.5	160	7	8960	Pinch Left and right extension	Medium to High Peak Force
"A" Decorator	6.8	530	3	12705	Ulnar deviation Wrist extension Shoulder flexion	Low
"A" Decorator[b]	15	240	5	9600	Wrist extension	Medium
Swiping 29" glass	13.8	262	12	25135	Wrist extension	High
Swiping Small Glass	14.4	250	13	26000	Wrist flexion Wrist extension	High
Swiping	14.2	254	13	26440	Wrist flexion Wrist extension	High
Swiping Table	41.5	87	8	5552	None	Low

a Cycle time expressed in seconds.
b This group includes inspectors.

(continued)

TABLE 6 (Cont.)
JOB ANALYSIS RESULTS
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

Job Name	Cycle Time[a]	Pieces per Hour	Movements per piece	Movements per day	Awkward Postures	Estimated Force
Polishing Oven Glass	160	22.5	40	7200	None	Medium
Polishing TV screens	120	30	60	14400	None	High
Polishing Furniture Glass (Curved)	270	13.3	91	9706	Wrist flexion	High
Polishing Furniture Glass (Impressioned)	165	22	30	5236	None	High
Swiping Mirrors	22.3	161	15	19372	Wrist Extension	High
Inspect/Pack Etched Glass	32	112	12	10800	None	Medium
Wash Mirrors	45	80	20	12800	None	Medium

a Cycle time expressed in seconds.
b This group includes inspectors.

TABLE 7
CUMULATIVE TRAUMA DISORDERS
QUESTIONNAIRE RESULTS
EAGLE CONVEX GLASS COMPANY
CLARKSBURG, WEST VIRGINIA
HETA 89-137

Department	Number	% with symptoms of CTS[a]	% with neck complaints	% with shoulder complaints
Administration	11	9%	18%	27%
Art	2	0	0	0
Box	1	0	0	0
Decorating	34	26%	35%	32%
Etching	7	29%	29%	43%
Furnace	22	0	0	9%
Mirror	20	25%	20%	20%
Maintenance	14	21%	14%	29%
Packer/Box	10	30%	20%	30%
Processing	54	27%	27%	31%

a CTS=Carpal Tunnel Syndrome

FIGURE 1

Chromatogram: Aromatic 150

Eagle-Convex Glass Company, Clarksburg, West Virginia

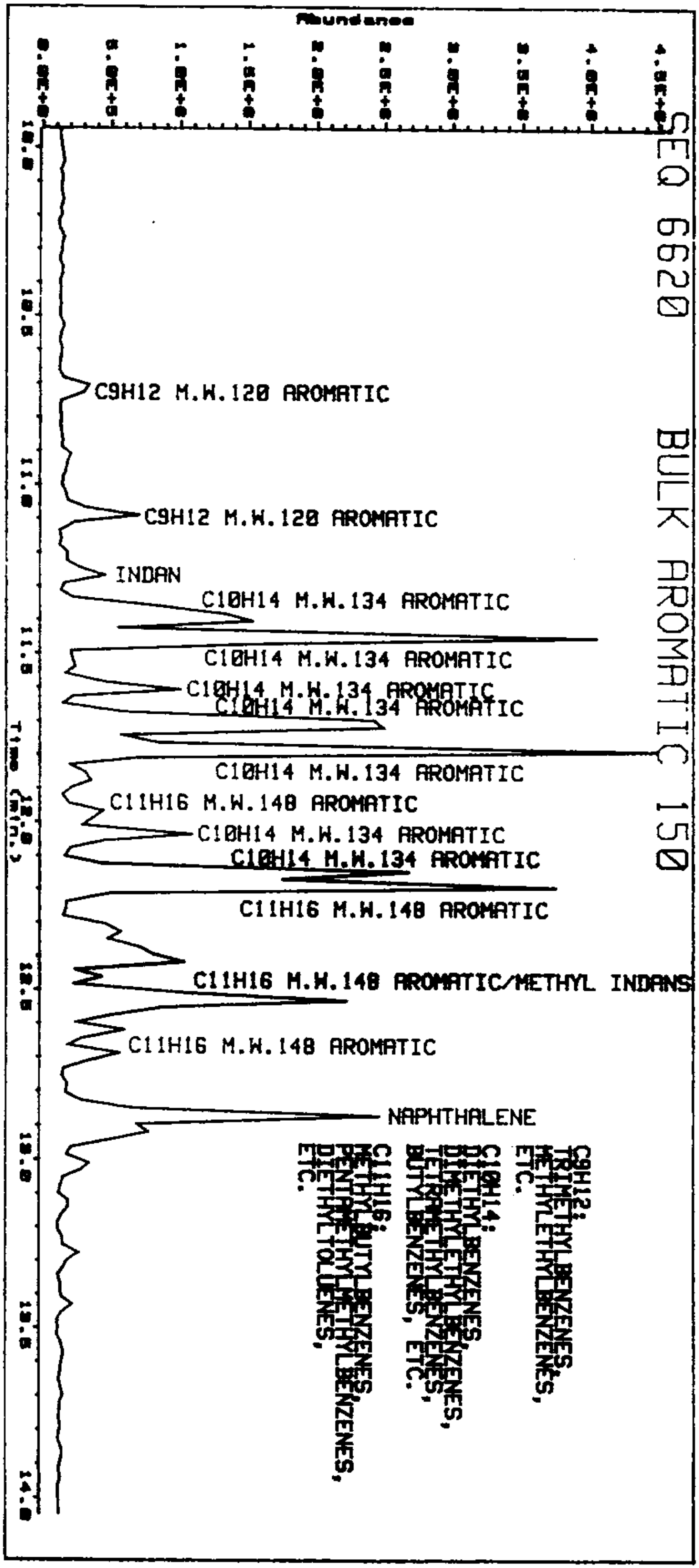


FIGURE 2
Chromatogram: 1086 Squeege Oil
Eagle-Convex Glass Company, Clarksburg, West Virginia

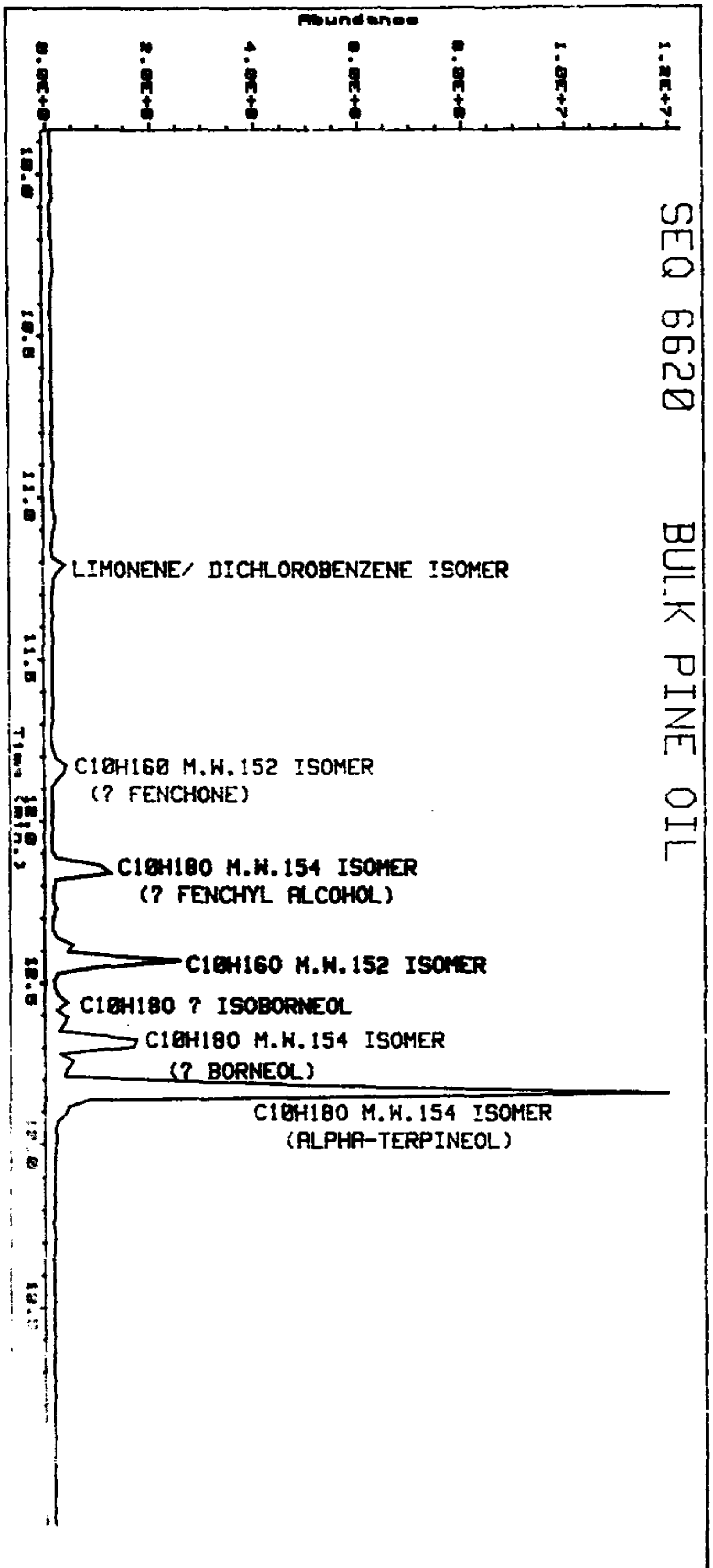
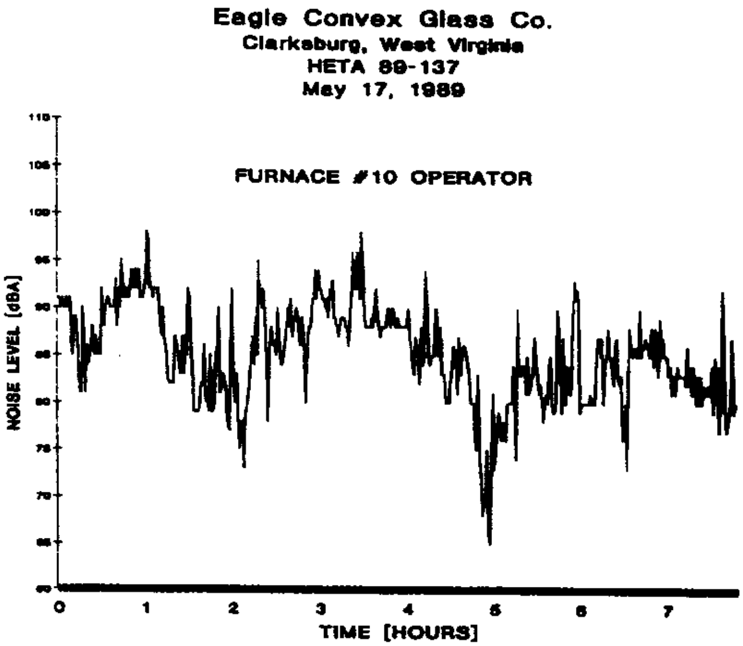
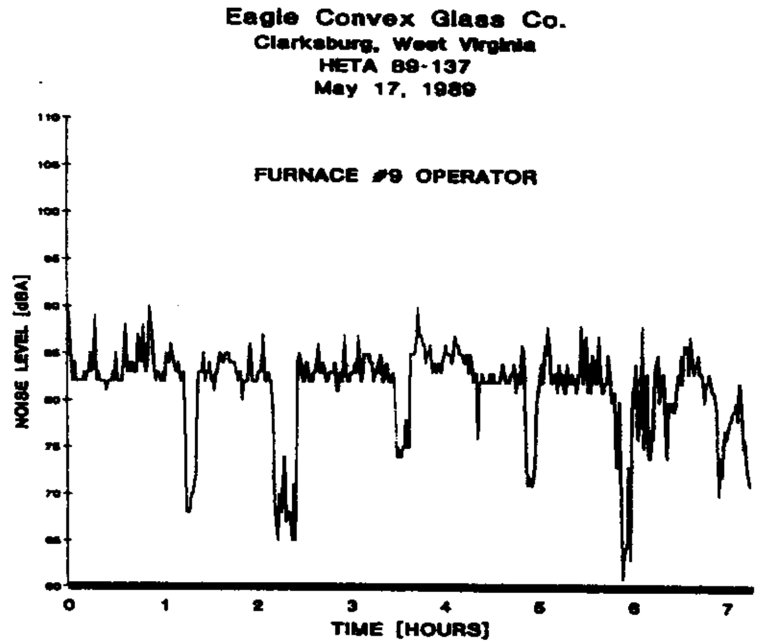


FIGURE 3


Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
FURNACE #10 OPERATOR
NOISE LEVEL [dBA]
0
1
2
3
4
5
6
7
TIME [HOURS]


Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
FURNACE #9 OPERATOR
NOISE LEVEL [dBA]
0
1
2
3
4
5
6
7
TIME [HOURS]

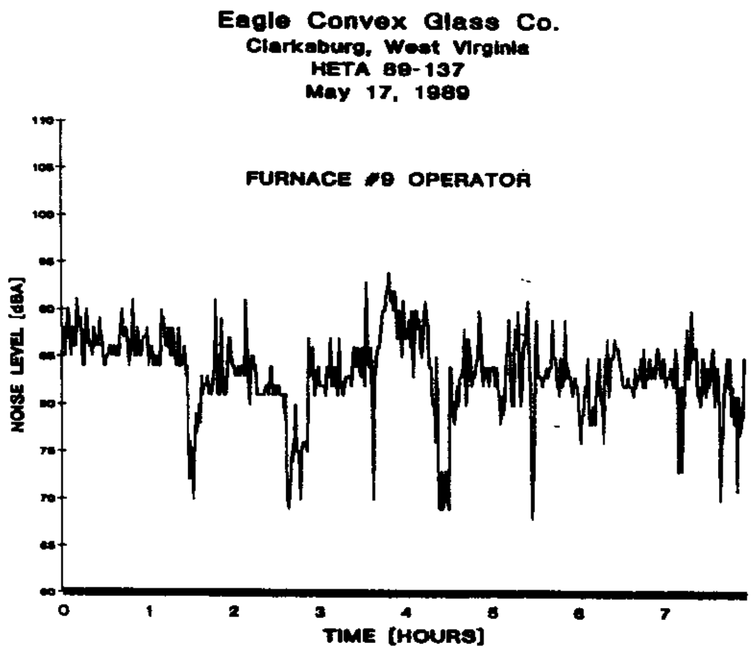
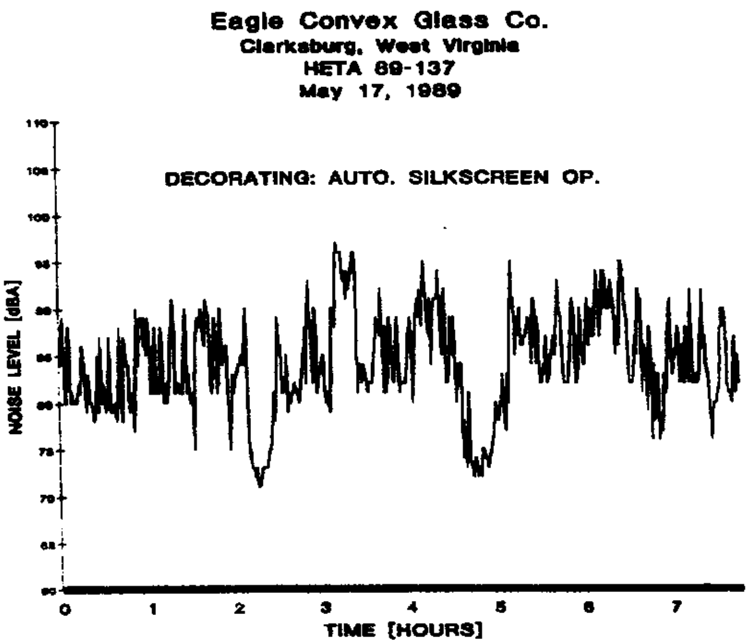
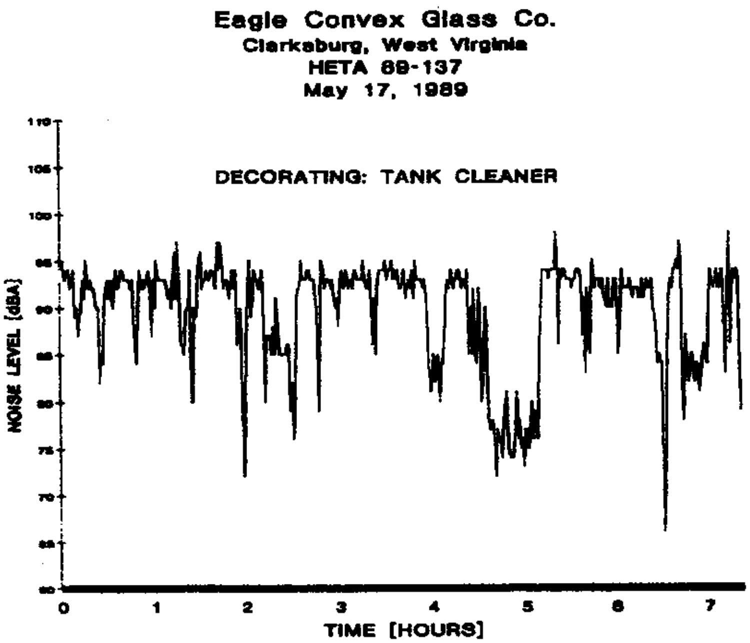

Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
FURNACE #9 OPERATOR
NOISE LEVEL [dBA]
0
1
2
3
4
5
6
7
TIME [HOURS]

FIGURE 4


Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
DECORATING: AUTO. SILKSCREEN OP.
NOISE LEVEL [dBA]
TIME [HOURS]


Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
DECORATING: TANK CLEANER
NOISE LEVEL [dBA]
TIME [HOURS]

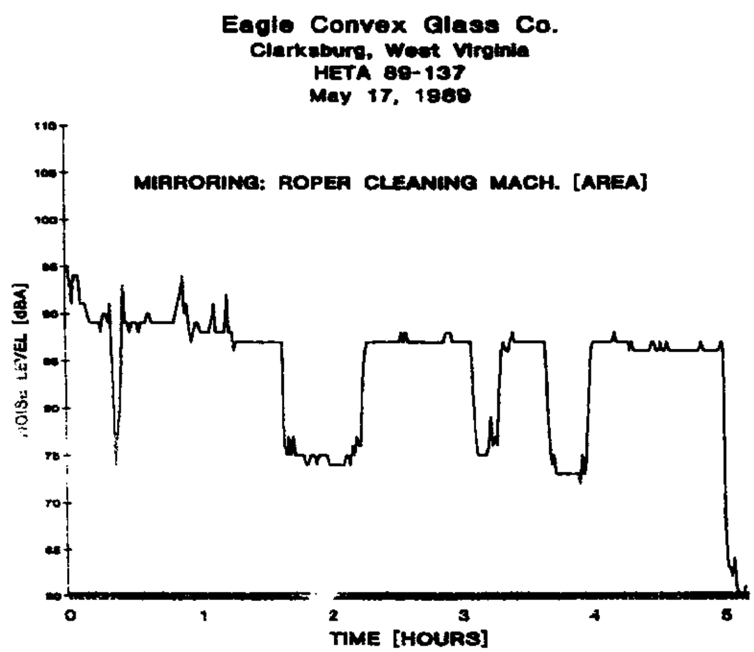
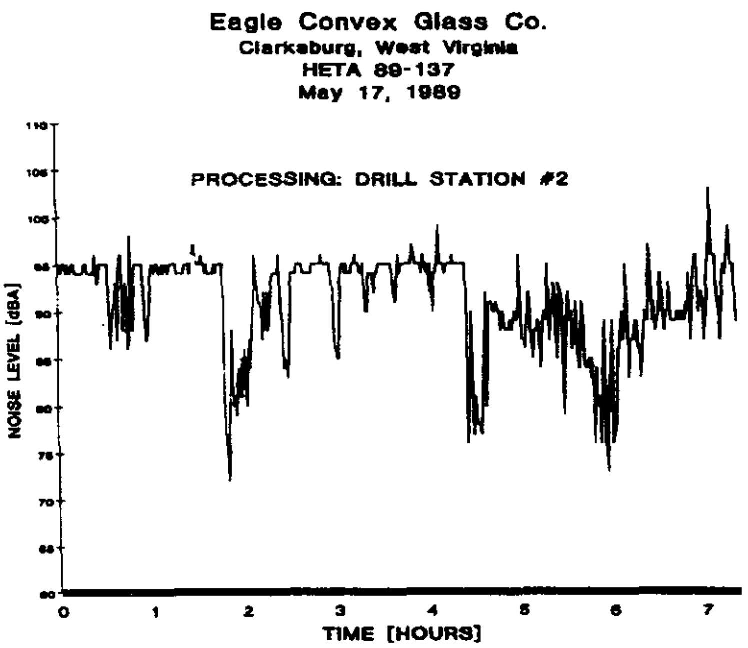
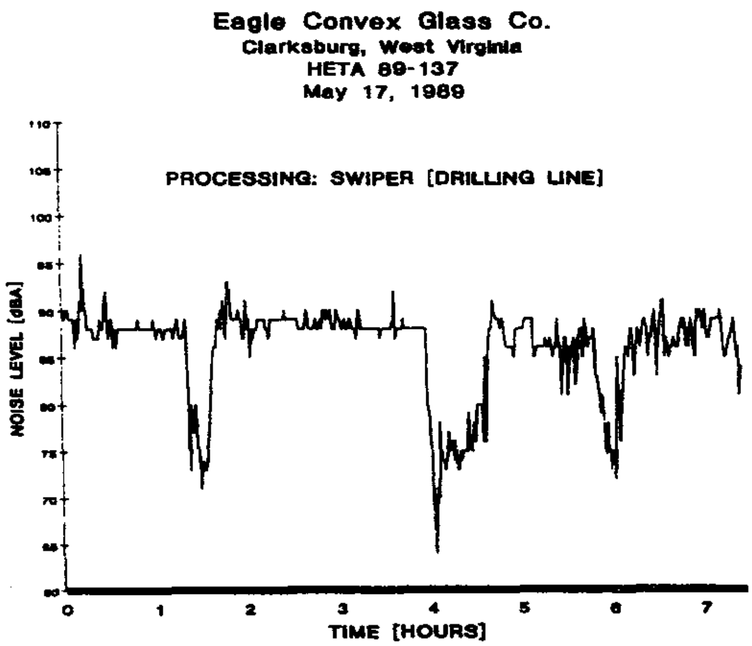

Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
MIRRORING: ROPER CLEANING MACH. [AREA]
TIME [HOURS]

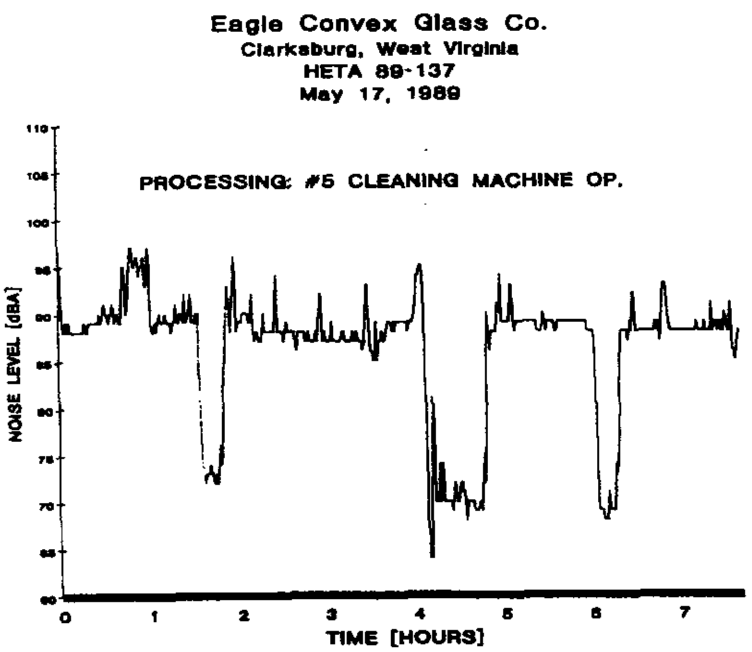
FIGURE 5



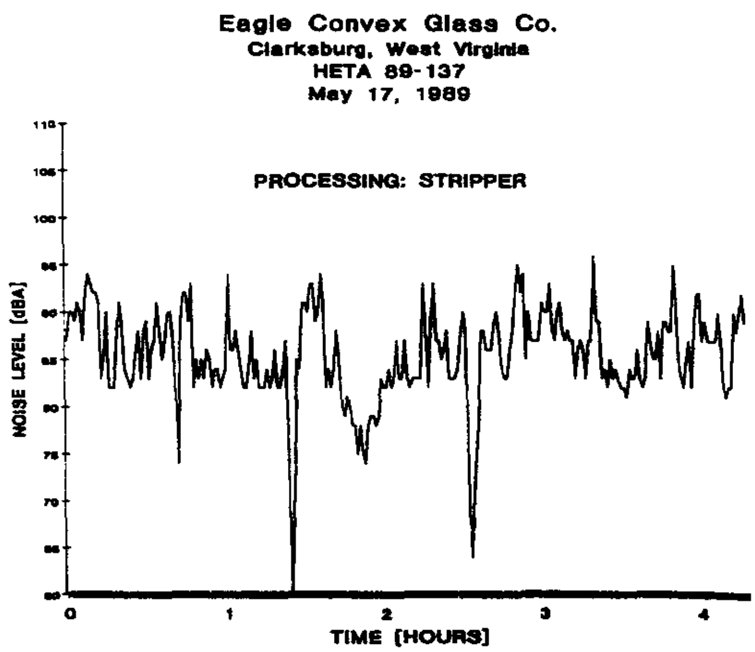
Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
PROCESSING: DRILL STATION #2
NOISE LEVEL [dBA]
TIME [HOURS]



Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
PROCESSING: SWIPER [DRILLING LINE]
NOISE LEVEL [dBA]
TIME [HOURS]

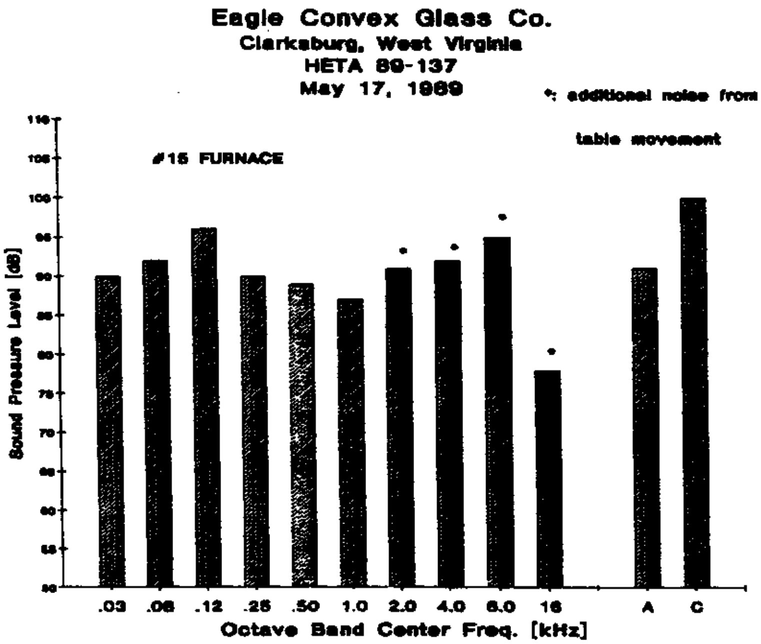


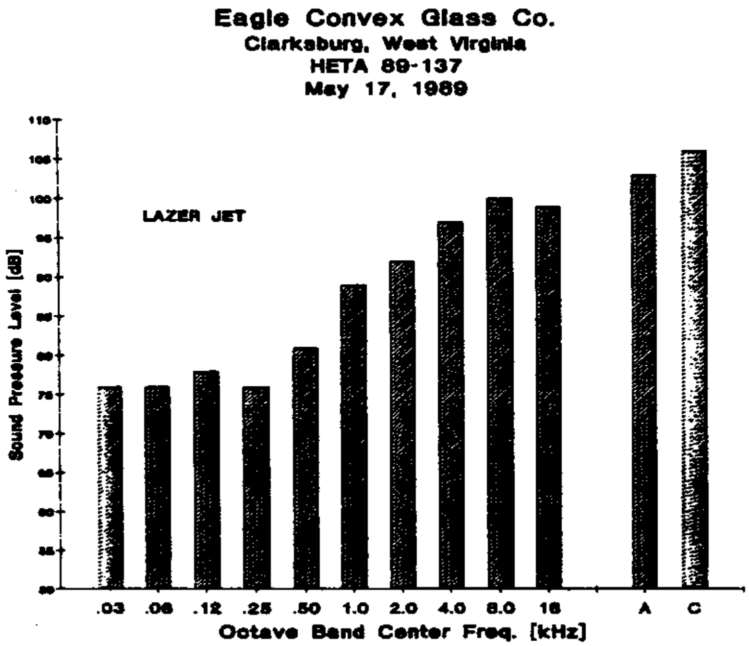
Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
PROCESSING: #5 CLEANING MACHINE OP.
NOISE LEVEL [dBA]
TIME [HOURS]

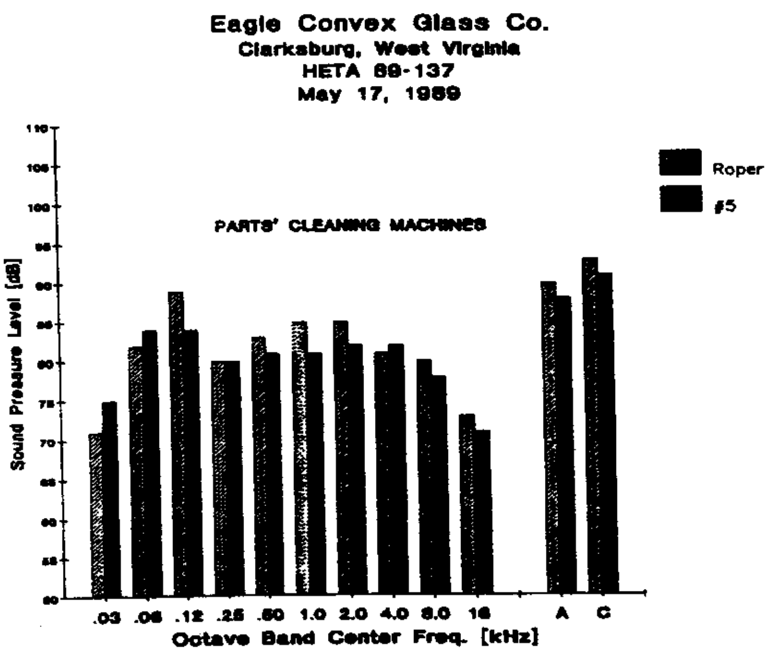


Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
PROCESSING: STRIPPER
NOISE LEVEL [dBA]
TIME [HOURS]

FIGURE 6


Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
*: additional noise from
table movement
#15 FURNACE
Sound Pressure Level [dB]
.03 .06 .12 .25 .50 1.0 2.0 4.0 8.0 16 A C
Octave Band Center Freq. [kHz]


Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
LAZER JET
Sound Pressure Level [dB]
.03 .06 .12 .25 .50 1.0 2.0 4.0 8.0 16 A C
Octave Band Center Freq. [kHz]


Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
Roper
#5
PARTS' CLEANING MACHINES
Sound Pressure Level [dB]
.03 .06 .12 .25 .50 1.0 2.0 4.0 8.0 16 A C
Octave Band Center Freq. [kHz]

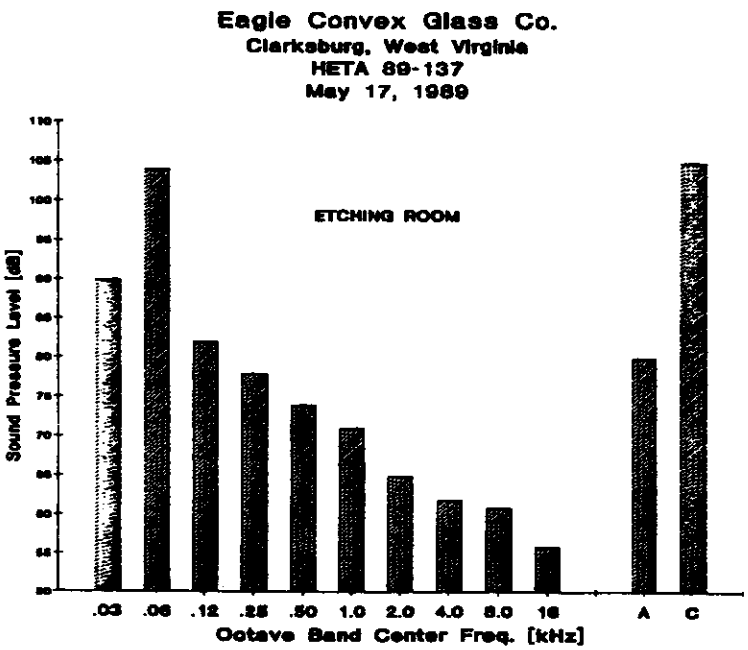

Eagle Convex Glass Co.
Clarksburg, West Virginia
HETA 89-137
May 17, 1989
ETCHING ROOM
Sound Pressure Level [dB]
.03 .06 .12 .25 .50 1.0 2.0 4.0 8.0 16 A C
Octave Band Center Freq. [kHz]

FIGURE 7

Example of a Slotted, Back-draft Work Bench

Eagle-Convex Glass Company

Clarksburg, West Virginia

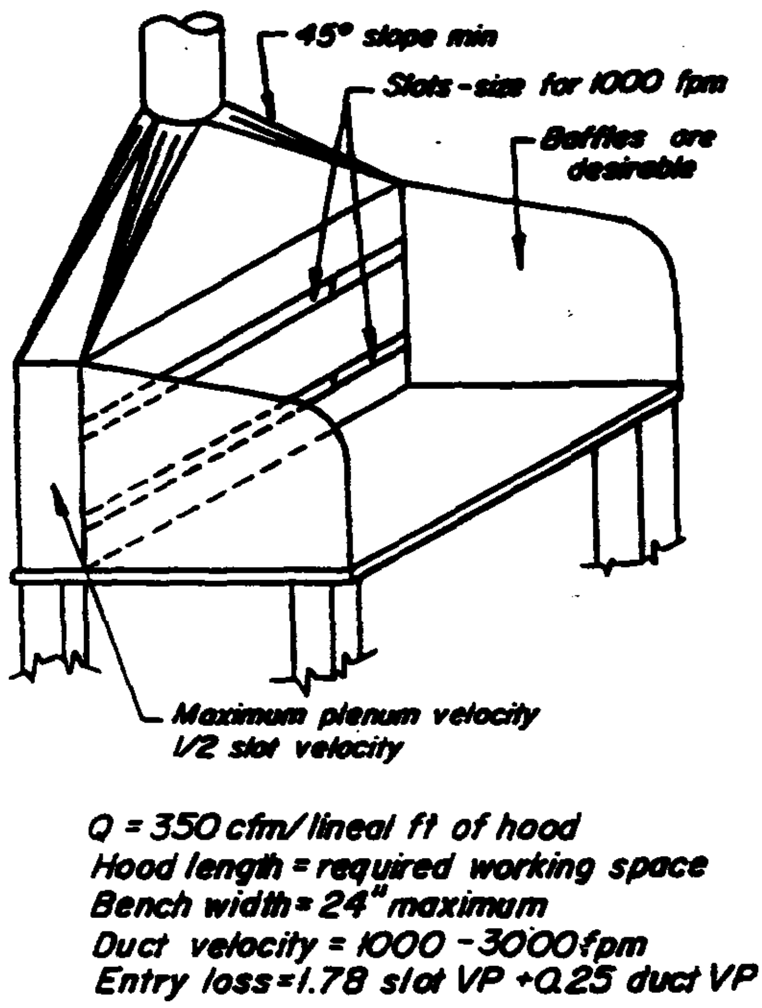


Figure courtesy of:

American Conference of Governmental Industrial Hygienists
Industrial Ventilation 19th Edition, 1986.
A Manual of Recommended Practice.