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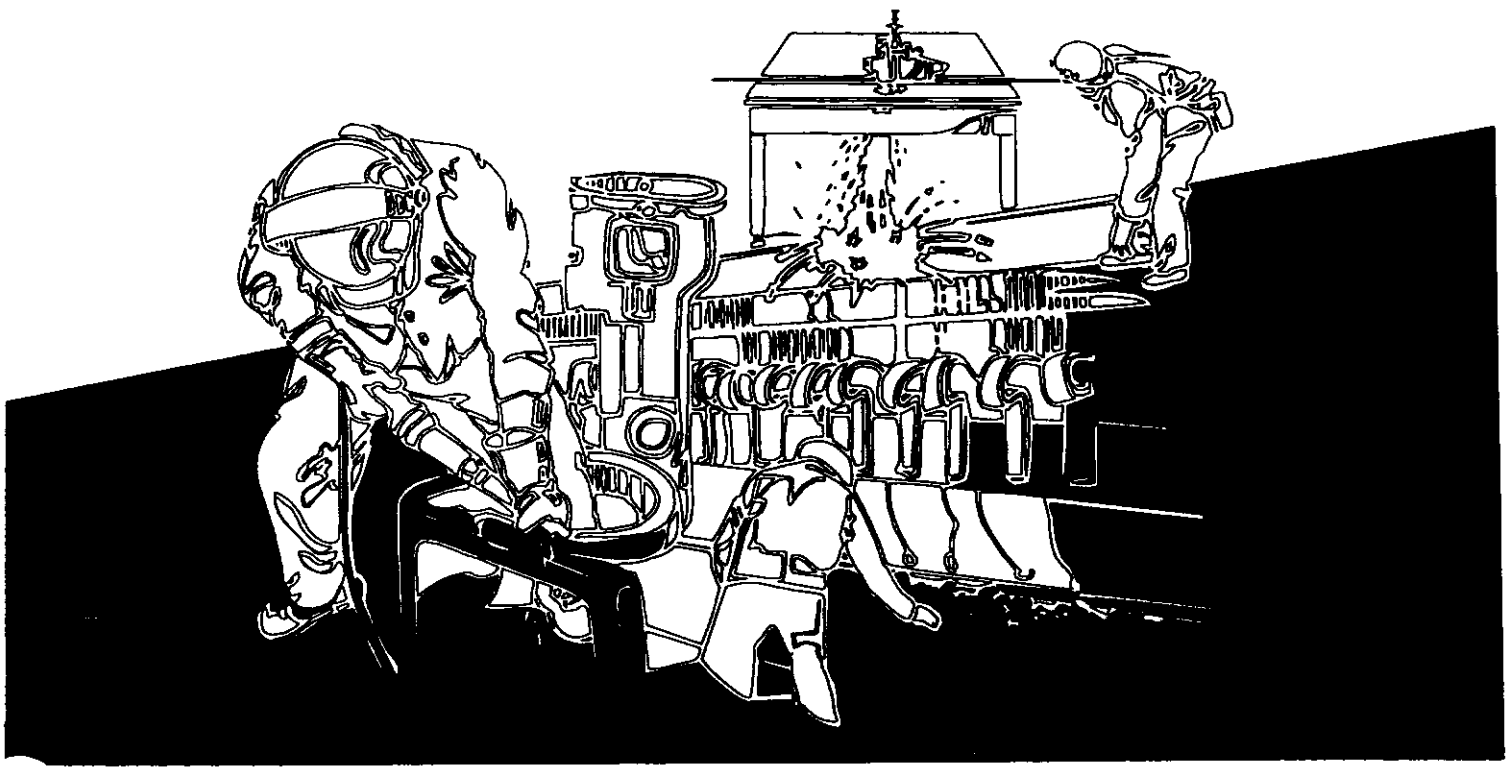
NIOSH

HEALTH HAZARD EVALUATION REPORT

HETA 89-267-2139
FLEXFAB, INC.
HASTINGS, MICHIGAN



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

CDC
CENTERS FOR DISEASE CONTROL

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 and 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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 89-267-2139
SEPTEMBER 1991
FLEXFAB, INC.
HASTINGS, MICHIGAN

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I. SUMMARY

In June 1989, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation at Flexfab, Inc. in Hastings, Michigan, to evaluate adverse health effects potentially related to workplace exposures. Specific health effects reported were lung and sinus problems and one case each of cirrhosis of the liver, Hodgkin's disease, and cancer of the liver. In September 1989, investigators from NIOSH conducted a site survey at Flexfab. In February 1990, a follow-up industrial hygiene survey was conducted to perform environmental sampling for silica used during milling, tetrahydrofuran (THF) used during a sealing operation, nitrosamines and other emissions from curing, and various solvents and release agents. Flexfab manufactures flexible hose, ducts, and connectors made from silicones, neoprenes, and other elastomers.

The environmental sampling results indicated that potential exposures to silica can occur during the milling of rubber with two filler products, Min-u-sil® and Hi-sil®. Air levels of total respirable silica ranged from less than 0.01 to 0.54 milligrams per cubic meter of air (mg/m^3), while the air levels of the respirable quartz fraction ranged from less than 0.02 to 0.35 mg/m^3. The results for the total respirable silica were below the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 6 mg/m^3, while some of the results for the respirable quartz were above the NIOSH Recommended Exposure Limit (REL) of 0.05 mg/m^3 and the OSHA PEL of 0.1 mg/m^3. These results did not indicate exposures exceeding these criteria because the samples were not 8-hour time-weighted averages (only short term), and because the samples with detectable quantities of quartz were either estimates (quantities detected between limit of detection and limit of quantitation) or high-volume samples collected with a Gast pump. However, since NIOSH considers the crystalline forms of silica to be potential occupational carcinogens, potential exposures should be reduced to the lowest feasible limits. The air concentrations of THF ranged between 20 parts per million (ppm) and 83 ppm. All these samples were below the OSHA, NIOSH, and American Conference of Governmental Industrial Hygienists (ACGIH) evaluation criterion of 200 ppm. However, the backup sections on three samples had more than 30% of the total analyte concentration, indicating breakthrough and that the actual concentrations were higher. Therefore, these samples would be near the action level of half (100 ppm) the evaluation criterion, at which point controls should be implemented. Both the operations involving these contaminants were

equipped with local exhaust ventilation, and recommendations to reduce potential exposures are included in this report. The sample results for the other contaminants were all below their relevant evaluation criteria.

Interviewed employees reported a variety of health effects, predominantly eye, mucous membrane, and respiratory tract irritation symptoms. Headaches and, less frequently, lightheadedness and drowsiness were also reported. These irritative and central nervous system symptoms may possibly be related to organic solvent exposure. A review of medical records and death certificates did not identify a pattern of diseases or cancers that could be attributable to a common workplace exposure.

During the initial site survey a problem with cumulative trauma disorders was apparent. Using OSHA 200 Logs and personnel data, estimated incidence rates for cumulative trauma disorders (CTDs) of the upper extremities were calculated. Incidence rates for years 1985 to 1989 ranged from 7 to 16 CTDs per 100 full-time employees. These rates were 21 to 47 times greater than the Bureau of Labor Statistics incidence rates for disorders associated with repeated motion, vibration, or pressure (a broad category that includes hearing loss, as well as CTDs) for the fabricated rubber products industry.

On the basis of this investigation, the NIOSH investigators conclude that workers operating the mills in the rubber room were at risk of exposure to crystalline silica and that workers applying the sealant to flexible utility ducts were exposed to levels of tetrahydrofuran near the action limit. In addition, there is a high incidence of upper extremity cumulative trauma disorders at this facility. Recommendations are made in Section VIII to modify the ventilation systems to reduce the potential for dust and chemical exposures. Methods to prevent and control cumulative trauma disorders are also provided.

KEYWORDS: SIC 3052 (Rubber and Plastics Hose and Belting) and SIC 3061 (Molded, Extruded, and Lathe-Cut Mechanical Rubber Goods) silica, tetrahydrofuran, rubber, hoses, flexible utility ducts, solvents, cumulative trauma disorders, quartz, nitrosamines.

II. INTRODUCTION

On June 5, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation at the Flexfab plant in Hastings, Michigan, to evaluate adverse health effects potentially related to workplace exposures. Specific health effects reported were lung and sinus problems and one case each of cirrhosis of the liver, Hodgkin's disease, and cancer of the liver. On September 6-7, 1989, a site survey was conducted to determine the nature, extent, and possible causes of the reported health effects. A letter summarizing the preliminary findings from the initial site visit was issued on October 2, 1989. A follow-up industrial hygiene survey was conducted February 7-9, 1990.

III. BACKGROUND

Flexfab, Incorporated is located in a one-story, 100,000-square-foot facility, set on a 23-acre site in Hastings, Michigan. Flexfab was founded in 1961 and manufactures lightweight, flexible, non-metallic parts for the automotive, trucking, aircraft and aerospace, and other industries as well as for the government and military. These products include flexible hose, ducts, and connectors made of silicones, neoprenes, and other elastomers. The facility employs a workforce of approximately 285 hourly employees and operates three shifts per day.

The tubes and hoses manufactured by Flexfab are primarily produced from silicone (70%) or neoprene (30%) rubber. Raw silicon rubber is received in 50-pound ingots, and raw neoprene is received in other bulk forms. The bulk rubber ingots are placed in mills, where catalysts, pigments, coagents, fillers, and other materials are added according to certain specifications. After the milling process, the rubber is calendered into wide, thin sheets. These sheets are then cut into shapes and strips for use in the different manufacturing processes. The bulk rubber may also be extruded into long coils called "hats" for use in the manufacture of hoses. Also, some of the rubber is received with the catalysts, pigments, etc. already milled.

After the raw rubber has been milled and either calendered or extruded, it is ready to be formed. Flexfab manufactures many different types of products; therefore, many of the products are handmade using specially cut pieces of the raw rubber in the special shapes department. The cut pieces of rubber are layered on predesigned mandrels. Other products are set on molds or are formed using lathes. During these processes, zinc stearate is used as a releasing agent. Many of the hose products are formed using automated machines. These include nylon wrapping machines used in the manufacturing of reinforced hoses.

At this point, the formed rubber is ready to be cured so that the products maintain their shape. Flexfab uses three different curing methods. The extruded hoses are cured at high temperatures in an

infrared oven, while the other products are cured in either a gas furnace or steam autoclave. After the rubber has been cured, the finished products get washed, trimmed, and inspected. Also, some of the rubber products require the attachment of metal parts using special glues in the bonding area.

Flexfab also manufactures a variety of air-handling flexible ducts. These ducts are produced in a separate building on the same site. The ducts are manufactured from a variety of fabrics such as neoprene-coated woven nylon or vinyl-coated woven polyester. The ducts are sewn together with an attached vinyl scuff strip. Flexfab receives the vinyl in pellet form and produces the scuff strip by extruding the pellets. Also, the vinyl-coated ducts are produced by dissolving the vinyl pellets in tetrahydrofuran and spray-applying the solution to the sewn ducts to produce the final product.

IV. METHODS

A. ENVIRONMENTAL

Personal breathing zone and general area air samples were collected from various areas throughout the facility (rubber room, special shapes, curing, sealing, etc.). These included samples for respirable particulates, respirable silica (quartz), tetrahydrofuran, total dust, metals, nitrosamines, and other organic compounds. Bulk samples of a silica-containing product, settled dust in the rubber room, and a white powder from a curing process were also collected. A local exhaust ventilation evaluation was performed on systems in the rubber room and sealing area using smoke tubes to determine airflow patterns and an Alnor Compuflow® thermoanemometer, model #8565, to measure air velocities.

The samples for respirable, total, and crystalline silica were collected with the same sampling train, which consisted of a 10-mm nylon cyclone with a 5-micron polyvinyl chloride (PVC) membrane filters connected via flexible tubing to a personal sampling pump operating at a flow rate of 1.7 liters per minute (lpm). Two high-volume air samples were also collected on PVC filters, with a stainless steel cyclone, attached via flexible tubing to a Gast sampling pump operating at a flow rate of 9 lpm. These samples were collected to verify the presence of silica at a low limit of detection. All these filters were first analyzed gravimetrically according to NIOSH Method 0500[1] to determine the total respirable silica fraction (based on the assumption that all respirable particulates are silica). These filters were then analyzed by X-ray diffraction for crystalline silica (cristobalite and quartz content) according to NIOSH Method 7500[1] with modifications. The

bulk samples of the silica-containing product and the settled dust from the rubber room were analyzed in the same manner.
The tetrahydrofuran (THF) samples were collected on charcoal tubes attached via flexible tubing to personal sampling pumps with a flow rate of 200 cubic centimeters per minute (cc/min). The charcoal tubes were then desorbed in 1 milliliter (ml) of carbon disulfide and analyzed according to NIOSH Method 1609[1] by a gas chromatograph (Hewlett-Packard Model 5731A) equipped with a flame ionization detector.

The other organic samples were collected using modifications of NIOSH methods, since multiple volatile organic compounds were collected on each sample. These compounds included acetone, ethanol, methanol, methyl ethyl ketone (MEK), toluene, 1,1,1-trichloroethane, trichlorofluoromethane, and trichlorotrifluoroethane. All these samples, except methanol, were collected on activated charcoal sorbent tubes; methanol was collected on silica gel sorbent tubes. All the sorbent media were attached via flexible tubing to personal sampling pumps with flowrates of either 50 or 200 cc/min. The samples were desorbed in 1 or 1.5 ml of carbon disulfide (some samples were desorbed in carbon disulfide containing internal standards or desorbing aids). The methanol samples were desorbed in 1 ml of water. All of these samples were then analyzed by gas chromatography with flame ionization detection. Some qualitative samples for volatile organic compounds were also collected using activated charcoal and ORBO-23 tubes. These samples were analyzed by GC/MS to identify other possible contaminants.

The samples for total dust and metals were collected on PVC filters attached via flexible tubing to personal sampling pumps operating at a flow rate of 2 lpm. These filters were first analyzed gravimetrically according to NIOSH Method 0500[1] to determine total dust. The filters were then analyzed for metals with a simultaneous scanning inductively coupled emission spectrometer (Thermo Jarrell Ash ICAP 61) according to NIOSH Method 7300.[1]

General area samples for nitrosamines were collected utilizing Thermosorb™/N tubes attached via flexible tubing to personal sampling pumps operating at a flow rate of 3 lpm. The tubes were desorbed with 2 ml of a solution of 25% methanol and 75% dichloromethane. The samples were then analyzed by gas chromatography/mass spectrometry (GC/MS) operated in the ion monitoring mode at a resolution of 3000. Specific N-nitrosamines were confirmed by monitoring the characteristic NO^+ ion at a mass-to-charge ratio (m/e) of 29.998 during expected chromatographic elution times.

The bulk sample of the white residue left after the curing process was analyzed by two methods to determine its composition. This bulk was analyzed by infrared spectroscopy and inductively coupled plasma - atomic emission spectroscopy.

B. MEDICAL

Approximately 35-40 employees were interviewed by NIOSH investigators. Some employees were interviewed informally during the walk-through survey, and 25 employees identified by the union as having concerns regarding potential workplace hazards were later interviewed in private. Those interviewed represented job positions in most of the 20 departments in the plant. The medical records of 6 employees who had sought medical attention for a health problem thought to be related to a workplace exposure were reviewed. In addition, a list of 9 deceased employees thought to have had a health problem related to a workplace exposure was compiled by union representatives and provided to NIOSH investigators. All 9 death certificates were obtained from the Michigan Department of Public Health and were reviewed. Lastly, the medical evaluation included a review of the OSHA 200 logs (1985 to 1989) for cumulative trauma disorders of the upper extremities. Estimated incidence rates for cumulative trauma disorders were calculated based on the number of reported cases in the OSHA 200 logs and personnel information supplied by the company.

V. EVALUATION CRITERIA

A. GENERAL

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 limits 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 limits. 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 limit 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 become available.

The primary sources of environmental evaluation criteria for the workplace are the following: 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 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 concentrations and the recommendations for reducing these concentrations found in this report, it should be noted that the lowest exposure criteria was used; however, industry is legally required to meet those limits 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 (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. SPECIFIC SUBSTANCES

1. Silica

Crystalline quartz silica causes silicosis, a fibrotic disease of the lungs.[5-7] The risk of developing silicosis and the rate of progression of the disease depends upon the amount of exposure to silica and the duration of exposure. A notable characteristic of silicosis is that the disease can progress even in the absence of further silica exposure. Symptoms of silicosis include cough, shortness of breath, wheezing, and repeated non-specific chest illnesses. Except in acute silicosis, symptoms generally do not occur until after 10-15 years of exposure. An important complication of silicosis is tuberculosis. There are two forms of chronic silicosis: simple and complicated. The simple form of silicosis is usually not a common cause of respiratory disability. However, the simple form may progress to complicated silicosis which can be associated with significant respiratory impairment. Acute silicosis, a distinct disease process, results from very high exposures to silica such as occurs during abrasive sand blasting and silica flour production. There is a rapid loss of lung function generally followed by death in 1 year.

The International Agency for Research on Cancer (IARC) reviewed the published data on silica and concluded that there was sufficient evidence indicating that silica is an animal carcinogen and limited evidence indicating that silica is a human carcinogen (primarily to the respiratory system).[8] NIOSH considers crystalline silica to be a potential occupational carcinogen.[9]

NIOSH recommends that occupational exposures to crystalline silica, as quartz, be controlled so that employees are not exposed to respirable concentrations greater than 0.05 milligrams per cubic meter (mg/m^3), determined as a TWA concentration for up to a 10-hour work shift in a 40-hour work week. Although NIOSH previously established this numerical REL (to protect against silicosis), the Institute currently recommends that exposures be reduced to the lowest feasible limit because it is not at present possible to establish a completely safe concentration for potential occupational carcinogens. NIOSH has also established an REL of 6 mg/m^3 for amorphous silica in the precipitated and gel forms.[10] OSHA has established PELs for quartz silica at 0.1 mg/m^3 and amorphous silica at 6 mg/m^3, both as 8 hour TWAs. The ACGIH TLV for quartz silica is also 0.1 mg/m^3, while the TLV for amorphous silica is 10 mg/m^3.

2. Organic Solvents

Acetone, ethanol, methanol, MEK, THF, toluene, trichlorofluoromethane, and 1,1,1-trichloroethane are organic solvents.[5] Many of the organic solvents are irritants of the eyes, mucous membranes, and upper respiratory tract. In addition, organic solvents can cause acute and chronic neurotoxic effects.[11] Acute neurotoxic effects include headache, lightheadedness, dizziness, weakness, poor concentration, incoordination, impaired balance, confusion, drowsiness, loss of consciousness, and respiratory depression. Other observed effects from excessive exposure include peripheral neuropathies and organic central nervous system (CNS) disorders.

Liver impairment has not been reported to be a significant health effect from occupational exposure to the above mentioned organic solvents. Only transient elevations in liver function tests were reported in two plumbers diagnosed with THF poisoning.[12] And only severe exposure to 1,1,1-trichloroethane has been associated with mild liver injury.[5]

The relevant evaluation criteria for THF, acetone, toluene, MEK, and 1,1,1-trichloroethane are listed below as TWAs in parts per million (ppm):

Compound	NIOSH	OSHA	ACGIH
THF	200	200	200
Acetone	250	750	750
Toluene	100	100	
MEK	200	200	200
1,1,1-trichloro-ethane	350	350	350

3. Nitrosamines

Nitrosamines are potent animal carcinogens. Nitrosodimethylamine (NDMA) has been shown to be the most potent carcinogen in the nitrosamine family. In animals, the target organs are the liver and kidney. Although nitrosamines are suspected to be human carcinogens, their carcinogenic potential in humans has not been proven.[5]

There are currently no standards for nitrosamines in air, except NDMA. NIOSH, the ACGIH, and OSHA recommend that NDMA be regarded as a potential occupational carcinogen and that exposure to it be controlled to the lowest feasible limit.[9]

4. Cumulative Trauma Disorders

Cumulative trauma disorders (CTDs) of the musculoskeletal system often occur in workers whose jobs require repetitive upper extremity exertion. These disorders include bursitis, ganglion cysts, musculoskeletal strain, synovitis, tendinitis, tenosynovitis, and/or numerous other specifically described musculoskeletal syndromes, including carpal tunnel syndrome. These disorders affect the nerves, tendons, and tendon sheaths of the upper extremity. 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.[13-26] 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. CTDs are considered in many cases to be work-related because these types of postures and movements are required in many manufacturing and assembly jobs in industry. Occupations for which a high incidence of CTDs have been reported include electronic components assembly, textile manufacture, small appliance manufacturing and assembling, meat processing and packing, fish filleting, and buffing and filing. 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 actual incidence of CTDs among these and other industries has not yet been established, but incidences as high as 44 cases per 100 workers per year have been reported.[27]

Although occupational factors are considered to be of major importance in the development of these disorders, there are also non-occupational antecedents of CTDs. Examples include hobbies and recreational activities such as woodworking, tennis, knitting, sewing, and playing musical instruments.[28,29] All of these pastimes impose physical demands on the musculotendinous system similar to those of the jobs mentioned above.

A common occupational CTD is carpal tunnel syndrome (CTS), a median nerve disorder. The clinical presentation of this syndrome includes pain and parathesias (burning and tingling sensation) in the hand along the distribution of the affected median nerve, precipitation of similar symptoms at night while sleeping, and possible radiation of pain to other portions of the involved arm/hand.[30-34] 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, wrist shape/size, congenital (at birth) defects, and gout.[35] Since a number of these conditions are unique to women, their risk of carpal tunnel syndrome 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 of CTS in men and women performing identical jobs. Silverstein et al. found that women and men were at essentially the same risk if performing identical job activities.[36,37]

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., 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 AND DISCUSSION

A. ENVIRONMENTAL

Tables I through IV present the results from the environmental sampling conducted during this evaluation. The results for the respirable silica, both total and quartz, are presented in Table I. Personal breathing-zone and general area samples were collected during two different milling operations in the rubber room. These operations were performed on the two mills located in the rubber room. The larger of the two mills was equipped with a local exhaust ventilation system consisting of enclosing hood, while the smaller mill was only equipped with a canopy-type hood. Both operations involved the milling of a filler into the bulk rubber. The two fillers used were Min-u-sil and Hi-sil®, which are both silica based. According to their respective material safety data sheets, Min-u-sil® contains approximately 98% crystalline silica, while Hi-sil® is composed of hydrated amorphous silica (silica gel). Bulk samples of the Min-u-sil® and settled dust from the rubber room were analyzed by X-ray diffraction to determine the actual crystalline content. The Min-u-sil® was found to contain 74% quartz, silica while the settled dust contained 22%. Cristobalite was not detected in either sample. A bulk sample of Hi-sil® was not collected.

The milling with Min-u-sil® was performed on the large mill. Two full-shift personal breathing-zone samples and one general area air sample were collected during the full shift, while a personal breathing-zone, general area air, and high-volume general area air samples were collected during the actual operation involving the Min-u-sil®. This included the transfer from a bag to a bulk container, weighing, and the actual milling process. These short-term samples were collected during the entire operation, which lasted approximately 50 minutes. During this operation, the large-mill operator was wearing a half-face respirator with high efficiency particulate air (HEPA) cartridges, while the small-mill operator was not wearing any personal protective equipment. As shown in Table I, only one sample of Min-u-sil®, besides the high-volume sample, had a detectable concentration of silica. This sample had a respirable silica concentration of 0.04 mg/m^3 and was collected during the full-shift from the small-mill operator. The high-volume sample was collected to ensure the presence of silica at detectable concentrations. This sample had a respirable silica

concentration 0.19 mg/m^3 and a respirable quartz concentration of 0.05 mg/m^3, which was between the limit of detection and the limit of quantitation. The respirable silica concentrations are based on the assumption that all of the respirable particulates are silica. This assumption may not be correct, but it is the best available estimate of the actual amorphous silica concentrations. The respirable quartz concentrations are actual, since X-ray diffraction analysis is specific for the different crystalline forms of silica, including quartz.

The milling with Hi-sil® was conducted mainly on the small mill; however, some milling was also performed on the large mill. The personal protective equipment used during this operation included a half-face respirator with HEPA cartridges worn by the large-mill operator, and a half-face paper, disposable mask worn by the small-mill operator, who had a beard. Two personal breathing-zone, one high-volume, and three general area air samples were collected during this operation, which was approximately 52 minutes in duration. The samples collected from an area on the large mill and the large-mill operator did not have detectable concentrations of either total or quartz silica. However, another area sample collected from the large mill did have a total silica concentration of 0.28 mg/m^3. Quartz was not detected on this sample. Two samples collected from the small mill and its operator had detectable concentrations for both total silica and quartz. The general area air sample from the small mill had concentrations of 0.34 mg/m^3 for total silica and 0.34 mg/m^3 for quartz, while the small-mill operator sample indicated concentrations of 1.0 and 0.35 mg/m^3 for total silica and quartz, respectively. However, the quartz concentrations in these samples were between the limit of detection (LOD) and the limit of quantitation (LOQ). The high-volume area sample collected during this activity indicated concentrations of 0.54 mg/m^3 for total silica and 0.13 mg/m^3 for quartz.

All the samples collected had concentrations well below the relevant evaluation criteria of 6 and 10 mg/m^3 for amorphous silica. However, four samples had concentrations of respirable quartz at or above the NIOSH numerical REL of 0.05 mg/m^3. One of these was the high-volume sample collected during the Min-u-sil® milling operation (0.05 mg/m^3). This value was between the LOD and the LOQ. Some quartz exposure was expected during this operation because the bulk sample of Min-u-sil® showed that this product contained approximately 74% quartz. Quartz was detected on three samples during the Hi-sil® milling on the small mill. The small-mill operator sample (0.35 mg/m^3), the general area sample collected from the small mill (0.34 mg/m^3), and the high-volume

sample (0.13 mg/m^3) were all above the NIOSH REL. While these results were also above both the OSHA PEL and ACGIH TLV of 0.1 mg/m^3, they were not expected because the material safety data sheet for Hi-sil® listed this product as containing hydrated amorphous silica (silica gel). A bulk sample of the Hi-sil® was not collected. Although the criteria are based on 8-hour TWAs, and these results have not been adjusted to reflect TWAs, they provide a conservative estimate of the potential for exposure since NIOSH considers crystalline silica to be a potential occupational carcinogen.

The results from the environmental sampling for organic solvents are presented in Tables II and III. Table II includes the results of the sampling conducted for THF during the sealing operation, while Table III provides the results for acetone, toluene, MEK and 1,1,1-trichloroethane from environmental sampling conducted throughout the entire plant.

Five samples were collected for THF (Table II) during the sealing operation performed on the utility blower hose products. This process includes dissolving polyvinyl chloride pellets in the THF. The resulting mixture is then sprayed onto the hoses in a partial enclosure adjacent to the manufacturing area. This enclosure (booth) has three side walls, a floor, and ceiling. The fourth side is open and is 48 feet long and 7 feet wide, and faces the manufacturing area. Ventilation is provided by 10 exhaust takeoffs in the back wall that draw air away from the manufacturing area. To perform the sealing, one employee enters the enclosed area and applies the mixture with a hand sprayer while the hose is rotated. The samples collected ranged from 20 to 83 ppm, with a sample duration averaging 428 minutes. None of the sample results was above the NIOSH, OSHA, or ACGIH evaluation criterion of 200 ppm. However, the backup sections on three samples had more than 30% of the total analyte concentration indicating breakthrough and that the actual concentrations were higher. These included the sealer (83 ppm) and areas on the pump (63 ppm) and on the wall behind the sealer (83 ppm). Therefore, the actual concentrations may be approaching half (100 ppm) the evaluation criterion, which typically indicates an action level where controls should be implemented. Vinyl chloride monomer was not included in the sampling protocol because the product was in the polymer form, and the material safety data sheet listed monomer contamination at less than 0.001%.

Table III includes the 16 samples collected from various employees and areas for organic solvents. These samples were analyzed for the solvents used where they were collected. Therefore, as indicated, the samples were not analyzed for all the compounds

listed in the table. Some samples were also analyzed for compounds not represented in Table III, but these results are not included because the compounds were not present at significant concentrations. All 16 of the samples were analyzed for acetone and had concentrations ranging from 0.53 to 212 ppm. Most of these concentrations were well below the evaluation criteria; however, two samples had concentrations that were nearing the NIOSH REL of 250 ppm. Both these samples were collected from locations in the Dept. 208 inspection area and indicated concentrations of 120 and 212 ppm. These concentrations were much higher than those determined on the other samples. Eleven of the samples were analyzed for toluene. These samples had concentrations of toluene ranging from 1.0 to 47 ppm. The sample collected at the Dept. 209 pad printer had a concentration (47 ppm) approaching half of the 100 ppm limit set by NIOSH, OSHA, and the ACGIH. Five general area samples collected from the pad printers and the inspection area were analyzed for MEK and had concentrations ranging from 0.38 to 23 ppm. Six personal breathing zone samples were also analyzed for 1,1,1-trichloroethane. Five of these samples had concentrations ranging from 2.4 to 4.1 ppm, while the remaining sample had an estimated concentration of 57 ppm, which was low because of breakthrough. The airborne concentrations of both MEK and 1,1,1-trichloroethane were well below their relevant evaluation criteria. Ethanol, methanol, and freons (both trichlorofluoromethane and trichlorotrifluoroethane) were also detected on some of the above samples, but at relatively low concentrations. Ethanol was detected on seven of the samples, with concentrations ranging from 2 to 8.5 ppm. Five of these concentrations, ranging from 4.8 to 8.5 ppm, are low estimates because breakthrough occurred. Two samples had detectable concentrations of methanol (2.4 and 3.4 ppm), while three samples had freon concentrations ranging from 0.2 to 0.5 ppm. All of the concentrations for these compounds were also well below their relevant evaluation criteria.

The results of the qualitative screen for other organic compounds identified many possible contaminants, including those reported above. The samples collected using the Orbo-23 tubes indicated that formaldehyde and traces of acetaldehyde were present. Estimated formaldehyde concentrations were as high as 0.1 ppm, which indicates additional sampling may be necessary. Major compounds identified on the charcoal tube samples were 1,1,1-trichloroethane, toluene, a dichlorobenzene isomer, and numerous polysiloxane compounds. Other compounds detected included MEK, benzene, 1-methoxy-2-propanol, octanes, methyl isobutyl ketone, xylenes, acetone, t-butanol, butylene oxide, ethyl acetate, ethanol, trichlorobenzene, trichlorofluoromethane, and some C_9-C_{11} alkanes.

Ten general area samples for nitrosamines were collected from locations near the different curing processes. Three of these samples were lost because of sampling pump failure, and one other sample was lost because the integrity of the sorbent media was violated. The remaining samples were analyzed; however, no nitrosamine compounds were detected on any of the samples, with detection limits ranging between 40 and 80 nanograms per sample.

Table IV presents the results of the sampling for total particulates and zinc. Ten samples were collected from lathe operators, the steam auto-clave operator, and three areas near these operators where the zinc stearate releasing agent is used. The total particulate concentrations ranged from 0.003 to 0.32 mg/m^3 while the zinc concentrations ranged from 0.002 to 0.12 mg/m^3. All of these concentrations were well below the relevant evaluation criteria.

The analysis of the white residue left after the curing process was not able to identify a specific compound. However, this residue was found to contain 0.11% zinc, by weight, which indicates that it may be partially composed of the zinc stearate releasing agent. Analysis by infrared spectroscopy determined that the residue possibly contained a thermally degraded component of zinc stearate and/or a mixture of other thermally degraded materials.

Ventilation evaluations were performed on two local exhaust units. One unit was originally designed to ventilate the two mills in the rubber room and the hat room, which is located adjacent to the rubber room. At the time of the survey, the supply damper and exhaust vents in the hat room were closed off. The other unit serviced the sealing booth where a mixture of THF and dissolved vinyl pellets is applied to the flexible utility ducts.

The two mills were located at the north end of the rubber room, near the wall that is common to the hat room. The ventilation system (see Figure 1) consisted of two canopy hoods with ducting, a baghouse, and a centrifugal fan, which exhausted and recirculated air from/to both the rubber and hat rooms. The area containing the mills is part of a larger area that is generally served by a separate forced-air heating, ventilation, and air-conditioning (HVAC) system. The large mill is partially enclosed with plexiglass side shields and a canvas curtain that are used when powdered products are milled into the rubber. The small mill is not equipped with such shields. The centrifugal fan for this ventilation system is controlled with an on/off power switch. The system is also equipped with solenoid operated dampers that regulate whether the system recirculates plant air or introduces outside air. The branch to the small mill has a manually operated

damper to control the air flow to this mill. This damper can be closed to prevent air flow from the small mill. The ventilation system is operated when powdered products are being used. Recirculation is always used (to save heating and cooling costs), except during the initial start-up of the system. Outside discharge mode is used during start-up because the bag house may release dust into the work area due to the initial pressure surge if the recirculation mode was selected. After a short time, the mode is switched to recirculation by the operator.

The side shields and curtain on the large mill appear to provide good control of the dust that is generated during the milling process. The air flow patterns and velocities indicated that most of the dust generated inside the enclosure would be captured; however, there was only a limited ability to capture dusts generated near the openings. Without side shields or a curtain, the small mill appeared unable to effectively control the dust that was generated during milling. When the damper to the small mill is closed, the flow at the large mill nearly doubles, thereby, increasing its capture efficiency. Also, the bag house pressure-differential gauge was not functioning properly. The gauge indicated a differential pressure of 0.2 inches of water (normal pressure differentials are usually 3 to 6 inches of water) indicating a leak or tear in the filter bag. This was determined not to be the case; however, because large amounts of dust were not being recirculated back to the rubber room. Another explanation may be that the pressure taps for this gauge may have been heavily clogged with dust.

The sealing booth contains the operation of applying a mixture of vinyl pellets dissolved in THF to flexible utility ducts. One operator applies the mixture with a hand-held spray applicator. The amount of time the operator spends in the booth varies because the operation is intermittent and the operators rotate. The booth is 48 feet long, 7 feet high, and approximately 8 feet in depth. There are ten exhaust vents located on the back wall which are aligned in two evenly spaced rows of five. One row is at floor level, and the other is at ceiling level. The ten vents are connected to a plenum which leads to an axial fan located on the roof. The face of the booth is also equipped with moveable curtains to help direct the flow of air towards the vents.

The wall exhaust vents in the sealing booth were all drawing air effectively. However, velocities at the face of the sealing booth were low and inconsistent, and the air flow patterns were easily disrupted by movement of the operator, general air flow around the booth, and a nearby ceiling fan. The curtain hanging at the face of the booth helped to stabilize the air flow; however, it was not

always used. Also, the operator would occasionally apply the mixture from a position between the flexible ducts and the exhaust vents. In this case, the exhaust ventilation carried the solvent vapors through the operator's breathing zone.

B. MEDICAL

Interviewed employees reported a variety of health effects, predominantly eye, mucous membrane, and respiratory tract irritation symptoms. Headaches, and less frequently, lightheadedness and drowsiness were also reported.

Medical records and death certificates were reviewed to determine if there were common diagnoses potentially related to a workplace exposure. A review of the medical records of 6 employees revealed 6 different health problems: "tracheal bronchitis", hypersensitivity pneumonitis, chronic pancreatitis, cirrhosis secondary to non A non B hepatitis, a healed granuloma found incidently on chest x-ray (CXR), and nonspecific mucous membrane and respiratory symptoms. Five of the 9 death certificates reviewed mentioned cancer: two breast cancers, one pancreatic, one lung, and one angiosarcoma of the spleen. Coronary artery disease was the cause of death for three of the four other employees, and diabetes for the remaining one. Except for lung cancer and silica exposure, these health problems have not been associated with specific exposures found at this plant. Because of the different types of health problems, it appears unlikely that they were associated with a common workplace exposure.

A review of the OSHA 200 logs revealed a total of 106 cases of cumulative trauma disorder (CTD) of the upper extremities for years 1985 to 1989, ranging from 14 to 33 cases per year (Table V). The two most common diagnoses were tendinitis and carpal tunnel syndrome. Other diagnoses reported included musculoskeletal strain, ganglion cyst, and DeQuervain's disease.

Using OSHA 200 logs and personnel information, estimated incidence rates (IR) for CTDs of the upper extremities were calculated. Irs were calculated by year and within each year by department; they are presented in Table VI. The annual Irs for upper extremity CTDs ranged from 7 to 16 CTDs per 100 full-time employees during the years 1985 through 1989. The Ford Auto department had the highest IR for 1985, 1987, and 1988, with 100, 33, and 67 CTDs respectively per 100 full-time employees. The Special Shapes (lathe and bench) department had the highest IR for 1986, with 22 CTDs per 100 full-time employees, and the Assembly department had the highest IR for 1989, with 40 CTDs per 100 full-time employees. Other departments with high Irs include the Lathe, Sewing, Rubber Room, Trim, Stripping, and Cutting Room departments.

This plant's rates can be compared to data from the U.S. Department of Labor, Bureau of Labor Statistics (BLS). Flexfab's incidence rates for years 1985 to 1989 were 21 to 47 times greater than the BLS incidence rates for disorders associated with repeated motion, vibration, or pressure for the fabricated rubber products industry, not elsewhere classified (Standard Industrial Classification [SIC] code #306, data for SIC code #305 [Gaskets, packing, and sealing devices and rubber and plastics hose and belting] was not provided) (Table VII).

The BLS incidence rate includes other disorders besides CTDs, notably noise-induced hearing loss. Yet, despite this, the BLS rate is still much lower than Flexfab's rate for CTDs.

Unfortunately, it is unlikely that the BLS rates reflect the actual rate of CTDs in industry. BLS data are based on records which employers maintain under the Occupational Safety and Health Act (i.e., OSHA 200 logs). OSHA 200 log information is likely to underreport acute and chronic musculoskeletal injury due to differences in individual interpretation of the meaning of a "recordable event" and due to the tendency of some physicians not to label CTD's as "work-related," perhaps because of lack of awareness of work-related causes, lack of exposure information, or the presence of non-occupational risk factors. Disher et al. reported such a lack of completeness of OSHA log data when they reviewed illness/injury histories of a cohort of 2040 workers via direct medical survey, OSHA log recording of the events, and Workers' Compensation recording of the events.[38] Fine et al. found that in a cohort of automobile manufacturing workers the incidence of recorded musculoskeletal injury was from 4 to 93 times greater when determined from company medical log data than from the OSHA log.[39]

There are several limitations to consider when interpreting the results from the Flexfab plant. Irs of CTDs by department may have been overestimated due to the relatively small numbers of workers in individual departments. Furthermore, these Irs by department did not adjust for transfers between departments, which may have falsely elevated or lowered the calculated Irs for some departments. Lastly, only OSHA 200 logs were used to identify cases of CTDs; possibly more cases could have been identified if other sources had been reviewed (e.g., Worker's Compensation records).

VII. CONCLUSIONS

The environmental air sampling results indicated that workers operating the mills in the rubber room are at risk of exposure to crystalline silica, and that workers applying the sealant to flexible utility ducts

are exposed to concentrations of THF near the action limit. Modifications to the ventilation systems in these areas should help to reduce the potential for exposure.

Irritative and central nervous system symptoms reported by some workers may be related to organic solvent exposure. Organic solvent exposure has been associated with the eye, mucous membrane, and respiratory tract irritation symptoms and central nervous system effects (i.e., headaches, lightheadedness, and drowsiness) reported by employees during the initial site visit. All organic solvent air concentrations were below their relevant evaluation criteria; however, two acetone air samples were nearing their NIOSH REL; one toluene air sample concentration was approaching half of the exposure limit set by NIOSH, OSHA, and the ACGIH; and THF concentrations approached the action limit. Whether exposure to low concentrations of several different organic solvents has a potentiating, synergistic, or cumulative effect is not known. Since cancers occurred at different anatomical sites, it is unlikely that, as a group, they were associated with a common workplace exposure.

Based on Irs calculated from OSHA 200 logs, there is a high incidence of upper extremity CTDs at this plant. High-risk departments include the Ford Auto, Special Shapes, Assembly, Lathe, Sewing, Rubber Room, Trim, Stripping and Cutting Room departments.

Flexfab has attempted to reduce the CTD risk among its workers. Over the last several years, Flexfab has instituted several changes in the work environment to reduce cumulative trauma disorders, including installing height-adjustable work tables, providing ergonomically designed tools (e.g., knives and snippers), and altering or automating some job processes to minimize the amount of repetitive motion. Flexfab's Central Safety Team, a joint employee-management committee, has conducted job safety analyses that resulted in changes in work processes. In addition, it was stated by management that Flexfab has brought in ergonomic experts and sent management personnel to ergonomic training programs.

VIII. RECOMMENDATIONS

1. Since NIOSH considers crystalline silica to be a potential occupational carcinogen, exposures should be reduced to the lowest feasible concentration. Engineering controls should be implemented where they are feasible. Respirators should be used unless engineering controls are shown by exposure monitoring to effectively eliminate the potential for employee exposures. Whenever respirators are used, a program for proper selection, use, and maintenance consistent with the guidelines found in "A NIOSH Guide to Industrial Respiratory Protection" (DHHS (NIOSH) Publication No. 87-116) and meets the requirements of OSHA regulations (29 CFR Part 1910.134) should be developed.

2. Improvements to the ventilation system located in the rubber room:

   a. The large mill is equipped with side shields and a curtain to prevent dust generated during milling from escaping to the environment; the small mill should also be equipped with similar containment.

   b. The taps and lines for the bag house pressure-differential gauge should be cleaned, since the gauge is not functioning properly. Also, the gauge should be monitored at regular intervals to assure proper filtration.

   c. The hat room should be supplied with dilution ventilation when being used. This could be accomplished by opening the supply damper and one exhaust vent in the room. The supply damper should also be moved downstream of the outside discharge damper. Solenoid-operated dampers, controlled by 2-way switches in the hat room and by the mills (or both), could allow full flow to the hat room, mills, or both. The exhaust should be fitted with an appropriate hood and grille. If air is supplied to both the hat room and the mills, the fan should be checked to determine if it could provide adequate airflow from all points served.

   d. A damper-controlled, exhaust takeoff in the hat room should be connected to a local exhaust enclosure for the bag dumping operation where Min-u-sil® and Hi-sil® are put into a bulk containers. Examples, excerpted from the ACGIH publication "Industrial Ventilation - A Manual of Recommended Practice," are included in Figure 2. This exhaust should remain on whenever the dilution system in the hat room was operating. This could be accomplished by installing a solenoid controlled damper activated by the same switches as the dilution exhaust vents and supply damper. Total exhaust in this room (i.e. local plus dilution) should be slightly more than the amount of air supplied to keep the hat room at a negative pressure when compared to the rubber room.

   e. Local exhaust ventilation should be considered for the weighing of powders and fillers taken from bulk containers.

   f. Flexfab is currently considering changing the ventilation system to 100% outdoor air, with an air-to-air heat exchanger, instead of recirculation. This change is recommended since air, possibly containing a potential occupational carcinogen, should not be recirculated. Insulating the air handler unit ducts should help to offset any higher energy costs resulting from use of the heat exchanger rather than recirculating air. Also, maintenance costs may be reduced with the heat exchanger,

since the high cost of cleaning the baghouse will be eliminated. In the meantime, as long as recirculation is used, standard operating procedures should contain instructions for when to use recirculation versus outside discharge (i.e. initial start of system).

3. Improvements to the ventilation system serving the sealing booth:

   a. To effectively capture the contaminants generated during the sealing operation, the face velocities across the opening may need to be increased. To help increase the face velocities across the opening of the booth and reduce the airflow disruptions, extension baffles should be added along the top and sides of the booth to increase the depth of the booth and to increase the distance between the work area and turbulent air flow zone near the face. Also, the nearby ceiling fan should be moved to a location away from the face of the booth.

   b. If further increases in the face velocities at the opening are needed, the axial-type fan presently being used in this system may need to be replaced with one (i.e. larger or different type) that would provide an increased volumetric airflow rate to the system. A centrifugal fan, for example, may increase the flowrate as well as be more suited to the material being exhausted (i.e. self cleaning). A ventilation consultant would be qualified to recommend an appropriate fan.

   c. The work area and application operation should be modified so that the operator applying the sealant does not work in the area between the ducts and the back wall of the booth. The operators should only apply the sealant with the ducts between them and the exhaust vents.

4. A preventive maintenance program for both these ventilation systems (rubber room and sealing booth) should be implemented. This should include inspection of the fan and ducts for any build-up of the sealing mixture. The fan belts and motors should also be inspected on a regular basis to assure proper performance.

5. Since formaldehyde was detected and estimated to be at concentrations of concern, additional environmental monitoring for this compound should be performed.

6. Good housekeeping practices for work with solvents should be followed and enforced. Proper solvent containers should be used at all times, and solvent rags should be discarded or placed in appropriate containers when not in use. Employees who use solvents and are at risk of skin exposure should wear gloves non-permeable to solvents.

7. Silica exposure causes silicosis and has been associated with respiratory cancer. Recommendations to reduce silica exposure to the lowest feasible limit have been outlined. To detect silicosis before symptoms develop workers potentially exposed to silica should have periodic CXRs. The CXR should be interpreted by a "B" reader or a radiologist with comparable expertise using the standard international system for pneumoconioses.[40] If the CXR is abnormal the employee should be notified and be referred for further clinical evaluation to establish whether or not he/she has a work-related respiratory condition. In most cases, the clinical evaluation should include an appropriate medical history (including history of documented exposure to silica), physical exam, and spirometric testing (with measurement of diffusing capacity).

8. Prevention and management of CTDs:[41]

   a. Flexfab's joint labor-management safety committee should continue to address ergonomic issues. The committee should have representation from all affected departments. The responsibility of the committee should include making decisions on appropriate interventions, such as the purchase and use of new equipment and changes in work organization, and evaluating the effectiveness of interventions in reducing CTD symptoms.

   b. Provide specific training for the safety committee in health and ergonomic hazard surveillance and workstation and job evaluation techniques.

   c. Provide a variety of adjustable furniture, supports, and equipment for employees based on their height and weight and work methods.

   d. Provide training to employees on how to use adjustable workstations and equipment to optimize ergonomic advantage. Evaluate how equipment is being used and discuss advantages and disadvantages of equipment with users.

   e. Provide for appropriate medical management of employees with potential or diagnosed cumulative trauma disorders. An OSHA document on guidelines for the meatpacking industry includes medical management suggestions (Appendix A) which may be helpful for other industries.

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5. Department of Labor/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 Respirable Silica

Flexfab, Inc.
Hastings, Michigan
HETA 89-267
February 8-9, 1990

Sample Description	Sampling Time (min)	Sample Volume (liters)	Respirable Total Silica (mg/m^3)	Respirable Quartz* (mg/m^3)
Rubber Room Mill-GA	484	823	ND	ND
Sm.-Mill Operator-PBZ	451	767	0.04	ND
Lg.-Mill Operator-PBZ	492	836	ND	ND
Lg.-Mill Operator (Min-u-sil Milling)-PBZ	49	83.3	ND	ND
Lg. Mill (Min-u-sil Milling)-GA	45	76.5	ND	ND
High Volume (Min-u-sil Milling)**-GA	46	414	0.19**	(0.05)**
Lg.-Mill Operator (Hi-sil Milling)-PBZ	43	73.1	ND	ND
Lg. Mill (Hi-sil Milling)-GA	42	71.4	0.28	ND
Lg. Mill (Hi-sil Milling)-GA	42	71.4	ND	ND
Sm.-Mill Operator (Hi-sil Milling)-PBZ	51	86.7	1.0	(0.35)
Sm. Mill (Hi-sil Milling)-GA	52	88.4	0.34	(0.34)
Bulk Air (Hi-sil Milling)**-GA	43	387	0.54**	0.13**

Evaluation Criteria -			
	OSHA	6	0.1
	NIOSH	-	Ca 0.05
	ACGIH	10	0.1
	(for precipitated gel)	6	

GA - General Area Sample; PBZ - Personal Breathing-Zone Sample; ND - Not Detected; Lg. - Large; Sm. - Small; () - value between limit of detection (LOD) and limit of quantitation (LOQ); Ca - NIOSH considers the crystalline forms of silica to be potential occupational carcinogens

* Samples were analyzed for crystalline silica (quartz and cristobalite), only quartz was detected.

**High volume air sample (respirable particulates) collected using high-volume gast pump.

Table II

Personal Breathing-Zone and General Area
Air Concentrations of Tetrahydrofuran

Flexfab, Inc.
Hastings, Michigan
HETA 89-267
February 8-9, 1990

Sample Description	Sampling Time (min)	Sample Volume (liters)	Tetrahydrofuran (ppm)
Sealer - PBZ	433	86.6	83*
Production Assistant (maintanance) -PBZ	422	84.3	20
New pump and drum-GA	429	86.1	63*
Behind sealer on wall - GA	428	85.7	83*
Near wall fan where hoses are stacked-GA	426	85.3	27

Evaluation Criteria	OSHA	200
	NIOSH	200
	ACGIH	200

PBZ - Personal Breathing- Zone Sample
GA - General Area Sample

* breakthrough occurred on these samples; therefore, actual concentrations are higher than these values.

Table III
Personal Breathing-Zone and General Area
Air Concentrations of Volatile Hydrocarbons
Flexfab, Inc.
Hastings, Michigan
HETA 89-267
February 8-9, 1990

Sample Description	Sample Volume	Acetone	Toluene	MEK	1,1,1-Trichloroethane
Dept. 233 work bench-GA	22.5	4	-	-	-
Dept. 233 work bench-GA	22.7	2	-	-	-
Dept. 204 Special Shapes-GA	19.9	2	-	-	-
Lathe Operator-PBZ	94.9	1.5	1.1	-	3.3
Lathe Operator PBZ	91.8	1.2	1.0	-	2.4
Lathe Operator PBZ	91.6	2.5	1.1	-	3.8
Lathe Operator PBZ	79.8	0.53	4.7	-	57*
Dept. 204 Lathe Operator-PBZ	85.0	1.6	1.4	-	2.6
Dept. 204 Lathe Operator-PBZ	84.4	1.3	2.7	-	4.1
Cutting Room-GA	18.7	8.8	-	-	-
Cutting Room-GA	18.8	7.6	-	-	-
209 Pad Printer-GA	17.5	2.4	47	23	-
206 Pad Printer-GA	17.7	1.9	4.8	(0.38)	-
206 Pad Printer-GA	17.7	1.9	7.2	(0.77)	-
208 Inspection-GA	17.6	120	5.3	33	-
208 Inspection-GA	17.5	212	1.2	1.9	-
Evaluation Criteria	OSHA	750	100	200	350
	NIOSH	250	100	200	350
	ACGIH	750	100	200	350

GA-General Area, PBZ-Personal Breathing Zone, MEK-Methyl ethyl ketone
"-"-not analyzed, ( )-value was present between limit of detection(LOD) and limit of quantitation (LOQ)
*-breakthrough occurred on this sample; therefore, actual concentration is than higher than this value.

Table IV

Personal Breathing-Zone and General Area
Air Concentrations of Total Particulates and Zinc

Flexfab, Inc.
Hastings, Michigan
HETA 89-267
February 8-9, 1990

Sample Description	Sample Volume (liters)	Total Particulates (mg/m^3)	Zinc (mg/m^3)
Dept. 204 Special Shapes-GA	870	0.15	0.009
Dept. 204 Lathe Operator-PBZ	880	0.003	0.002
Dept. 204 Lathe Operator-PBZ	884	0.12	0.005
Dept. 204 Lathe Operator-PBZ	880	0.24	0.011
Dept. 204 Lathe Operator-PBZ	886	0.32	0.02
Dept. 233 (on table)-GA	908	0.10	0.003
Dept. 233 Lathe Operator-PBZ	912	0.32	0.023
Dept. 233 Lathe Operator-PBZ	918	0.31	0.036
Large Diameter Extrusion-GA	840	0.18	0.12
Steam Auto-Clave Operator-PBZ	816	0.06	0.002
Evaluation Criteria	OSHA NIOSH	15 -	10 5(as oxide) 10(as stearate)

TABLE V

Number of Reported Upper Extremity CTDs from
OSHA 200 Logs by Year

Flexfab,Inc.
Hastings, Michigan
HETA 89-267

Cumulative Trauma disorders	1985	1986	1987	1988	1989
Carpal Tunnel Syndrome	5	2	5	5	3
Ganglion Cyst	3	3	1	0	1
DeQuervain's Disease	0	1	1	1	1
Musculoskeletal Strain	7	5	1	3	8
Tendonitis[1]	1	3	7	20	12
Other[2]	0	0	3	4	0
Total	16	14	18	33	25

[1] includes tenosynovitis and epicondylitis

[2] includes ulnar tunnel, stress arthritis, nerve impingement, fascitis, and tendon soreness

TABLE VI

Incidence Rates[1] for OSHA Log-Recorded Upper extremity CTDs
by Year and Department

Flexfab,Inc.
Hastings, Michigan
HETA 89-267

Department[2]	1985	1986	1987	1988	1989
Lathe	7	0	3	13	0
Ford Auto	100	0	33	67	33
Sewing	4	4	0	22	14
Rubber Room	40	0	20	33	17
Special Shapes (Lathe)	0	0	0	0	24
Trim	25	0	17	25	8
Sleeve (Lay-up)	25	0	0	0	0
Inspection/Shipping	0	0	0	0	23
Assembly	0	0	0	0	40
Stripping	11	0	22	10	0
Cutting Room	0	9	9	17	8
Lab	0	0	0	17	0
Special Shapes (Bench)	0	0	0	0	12
Large Diameter Formed Hose	0	0	0	0	33
Special Shapes[3] (Lathe & Bench)	7	22	17	23	0
Inspection[3] (shipping & special shapes)	0	0	12	6	0
All Departments	8	7	9	16	12

[1] The number of upper extremity CTDs per 100 full-time employees reported during the year.
[2] No upper extremity CTDs were reported for the following departments: Receiving, Extrusion, Maintenance, Chysler Elbow, Model Shop, Inspection (Special Shapes).
[3] The area a person worked within the department was not specified in the OSHA 200 Logs from 1985 to 1988. To calculate the IRs, the two areas within the department were combined.

TABLE VII

Comparison of Flexfab's Incidence Rates[1] of CTDs
with BLS Incidence Rates[2]

Flexfab,Inc.
Hastings, Michigan
HETA 89-267

	YEAR				
	1985	1986	1987	1988	1989
Flexfab (All Depts)	8	7	9	16	12
BLS (SIC Code 306)	0.17	0.26	0.27	0.57	0.57
Rate Ratio[3]	47	27	33	28	21

[1] The number of upper extremity CTDs per 100 full-time employees reported during the year.

[2] The Bureau of Labor Statistics (BLS) incidence rates for disorders associated with repeated motion, vibration, or pressure (this includes CTDs) for the fabricated rubber products industry (Standard Industrial Code [SIC] code #306).

[3] The rate ratio (RR) is the ratio of Flexfab's incidence rate to the BLS incidence rate for CTDs.

FIGURE 1

(VENTILATION SYSTEM FOR RUBBER MILLS)

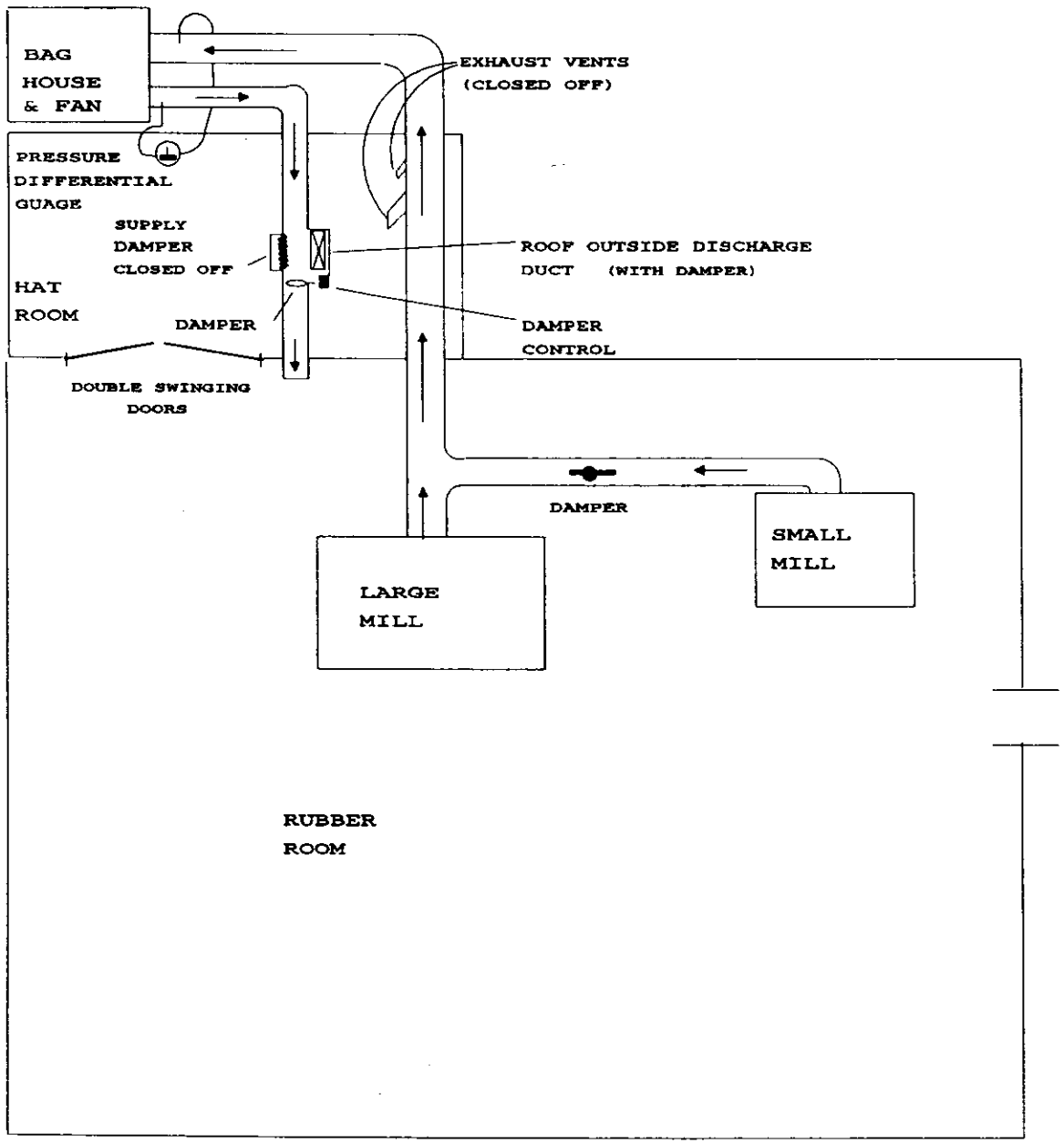


FIGURE 2

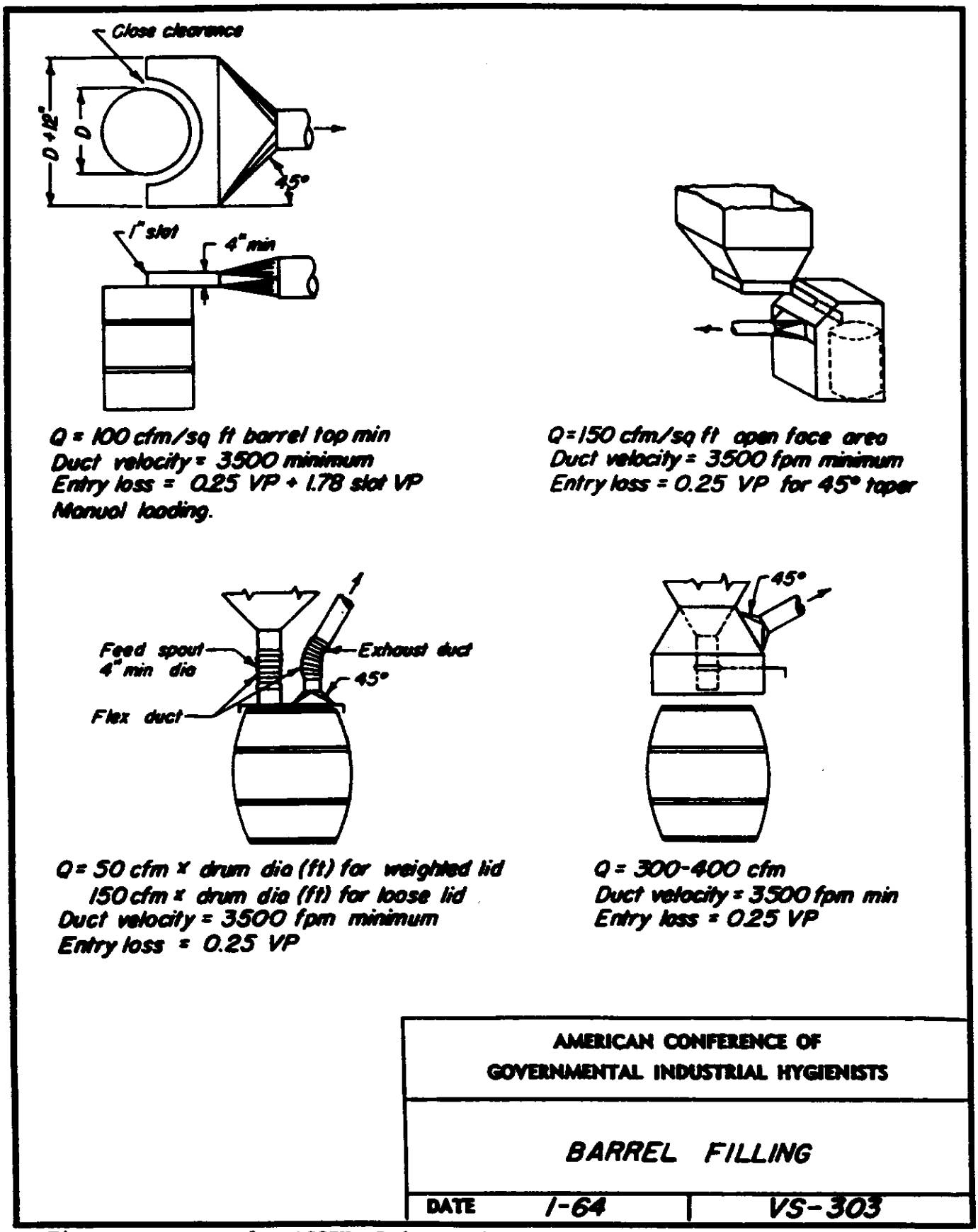


Figure courtesy of: ACGIH, Industrial Ventilation: a manual of recommended practice. 20th edition. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1988.

APPENDIX A

Medical Management

These medical management guidelines were obtained from the 1991 OSHA publication "Ergonomics program management guidelines for meatpacking plants" (OSHA 3123). Although these guidelines were intended for the meatpacking industry, the suggestions for medical management of cumulative trauma disorders may be helpful in other industries.

C. *Medical Management Program for the Prevention and Treatment of Cumulative Trauma Disorders in Meatpacking Establishments*

1. General

As noted in several sections of these guidelines, an effective medical management program for cumulative trauma disorders (CTDs) is essential to the success of an employer's ergonomic program in the meatpacking industry.

It is not the purpose of these guidelines to dictate medical practice for an employer's health care providers. Rather, they describe the elements of a medical management program for CTDs to ensure early identification, evaluation, and treatment of signs and symptoms; to prevent their recurrence; and to aid in their prevention. Medical management of CTDs is a developing field, and health care providers should

monitor developments on the subject. These guidelines represent the best information currently available.

A physician or occupational health nurse (OHN) with training in the prevention and treatment of CTDs should supervise the program. Each work shift should have access to health care providers in order to facilitate treatment, surveillance activities, and recording of information. Where such personnel are not employed full-time, the part-time employment of appropriately trained health care providers is recommended.

In an effective ergonomics program, health care providers should be part of the ergonomics team, interacting and exchanging information routinely to prevent and properly treat CTDs. The major components of a medical management program for the prevention and treatment of CTDs are trained first-level health care providers, health surveillance, employee training and education, early reporting of symptoms, appropriate medical care, accurate recordkeeping, and quantitative evaluation of CTD trends throughout the plant.

For a definition of disorders associated with repeated trauma, also known as cumulative trauma disorders, see the Glossary.

2. Trained and Available Health Care Providers

Appropriately trained health care providers should be available at all times, and on an ongoing basis as part of the ergonomic program.

In an effective medical management program, first-level health care providers should be knowledgeable in the prevention, early recognition, evaluation, treatment and rehabilitation of CTDs, and in the principles of ergonomics, physical assessment of employees, and OSHA recordkeeping requirements.

3. Periodic Workplace Walkthrough

In an effective program, health care providers should conduct periodic, systematic workplace walkthroughs to remain knowledgeable about operations and work practices, to identify potential light duty jobs, and to maintain close contact with employees. Health care providers also should be involved in identifying risk factors for CTDs in the workplace as part of the ergonomic team.

These walkthrough surveys should be conducted every month or whenever a particular job task changes. A record should be kept documenting the date of the walkthrough, area(s) visited, risk factors recognized, and action initiated to correct identified problems. Followup should be initiated and documented to ensure corrective action is taken when indicated.

4. Symptoms Survey

Those responsible for the medical management program should develop a standardized measure of the extent of symptoms of work-related disorders for each area of the plant, to determine which jobs are exhibiting problems and to measure progress of the ergonomic program. (See Putz-Anderson, pp. 42-44, Selected Bibliography.)

a. *Institute a Survey.* A survey of employees should be conducted to measure employee awareness of work-related disorders and to report the location, frequency, and duration of discomfort. Body diagrams should be used to facilitate the gathering of this information.

Surveys normally will not include employees' personal identifiers; this is to encourage employee participation in the survey. Survey information should include information such as that discussed in Exhibit 1 (Symptoms Survey Checklist).

The survey is one method for identifying areas or jobs where potential CTD problems exist. The major strength of the survey approach is in collecting data on the number of workers that may be experiencing some form of CTD. Reported pain symptoms by several workers on a specific job would indicate the need for further investigation of that job.

b. *Conduct the Survey Annually.* Conducting the survey annually should help detect any major change in the prevalence, incidence, and/or location of reported symptoms.

5. Compile a List of Light-Duty Jobs

The ergonomist or other qualified person should analyze the physical procedures used in the performance of each job, including lifting requirements, postures, hand grips, and frequency of repetitive motion. (See Section III. A. and Putz-Anderson, pp. 47-73, Selected Bibliography.) Positions with ergonomic stress should be so labeled.

The ergonomist and health care providers should develop a list of jobs with the lowest ergonomic risk. For such jobs, the ergonomic risk should be described. This information will assist health care providers in recommending assignments to light or restricted duty jobs. The light duty job should therefore not increase ergonomic stress on the same muscle-tendon groups.

Health care providers should likewise develop a list of known high-risk jobs.

Supervisors should periodically review and update the lists.

6. Health Surveillance

a. *Baseline.* The purpose of baseline health surveillance is to establish a base against which changes in health status can be evaluated, not to preclude people from performing work. Prior to assignment, all new and transferred workers who are to be assigned to positions involving exposure of a particular body part to ergonomic stress should receive baseline health surveillance.

[*NOTE:* The use of medical screening tests or examinations have not been validated as predictive procedures for determining the risk of a worker developing a CTD.]

These positions should be identified through the worksite analysis program discussed in Sections II. A. and III. A. and from the list of known high-risk jobs compiled by the health care provider. The majority of employees in the meatpacking industry can be expected to be in high-risk jobs.

The baseline health surveillance should include a medical and occupational history, and physical examination of the musculoskeletal and nervous systems as they relate to CTDs. The examination should include inspection, palpation, range of motion (active, passive and resisted), and other pertinent maneuvers of the upper extremities and back. Examples of the pertinent maneuvers for the hands and wrists include Tinel's test, Phalen's test, and Finkelstein's test. (See Exhibit 2 of this Section.) Laboratory tests, X-rays, and other diagnostic procedures are not a routine part of the baseline assessment.

b. *Conditioning Period Followup*. New and transferred employees should be given the opportunity during a 4-to-6-week break-in period to condition their muscle-tendon groups prior to working at full capacity. (See Section II. B. 2. of the guidelines on "Work Practice Controls.") Health care providers should perform a followup assessment of these workers after the break-in period (or after one month, if the break-in period is longer than a month) to determine if conditioning of the muscle-tendon groups has been successful; whether any reported soreness or stiffness is transient and consistent with normal adaptation to the job or whether it indicates the onset of CTD; and if problems are identified, what appropriate action and further followup are required.

c. *Periodic Health Surveillance*. Periodic health surveillance—every 2 to 3 years—should be conducted on all workers who are assigned to positions involving exposure of a particular body part to ergonomic stress. The content of this assessment should be similar to that outlined for the baseline. The worker's medical and occupational history should be updated.

d. *Documentation*. Data gathered on workers as a result of health surveillance should be documented and filed in individual employee medical records.

7. Employee Training and Education

Health care providers should participate in the training and education of all employees, including supervisors and other plant management personnel, on the different types of CTDs and means of prevention, causes, early symptoms and treatment of CTDs. This information should be reinforced during workplace walkthroughs and the individual health surveillance appointments. All new employees should be given such education during orientation. This demonstration of concern and the distribution of information should facilitate the early recognition of CTDs prior to the development of more severe and disabling conditions and increase the likelihood of compliance with prevention and treatment.

8. Encourage Early Report of Symptoms

Employees should be encouraged by health care providers and supervisors to report early signs and symptoms of CTDs to the in-plant health facility. This allows for timely and appropriate evaluation and treatment without fear of discrimination or reprisal by employers. It is important to avoid any potential disincentives for employee reporting, such as limits on the number of times an employee may visit the health unit.

9. Protocols for Health Care Providers

Health care providers should use written protocols for health surveillance and the evaluation, treatment, and followup of workers with signs or symptoms of CTDs. The protocols should be prepared by a qualified health care provider. These protocols should be available in the plant health facility. Additionally, the protocols should be reviewed and updated annually and/or as state-of-the-art evaluation and treatment of these conditions changes. An example algorithm for the evaluation and treatment of upper extremity CTDs is included as Exhibit 3 of this Section. The date of review and signature of the reviewer should appear on each protocol.

10. Evaluation, Treatment, and Followup of CTD

If CTDs are recognized and treated appropriately early in their development, a more serious condition likely can be prevented; therefore, a good medical management program that seeks to identify and treat these disorders early is important. The following systematic approach, in general outline, is recommended in evaluating and following workers who report to the health unit.

a. *Screening Assessment*. Upon the employee's presentation of symptoms, the health care provider's screening assessment should include obtaining a history from the worker to identify the location, duration and onset of pain/discomfort, swelling, tingling and/or numbness, and associated aggravating factors. A brief non-invasive screening examination for the evaluation of CTDs consists of inspection, palpation, range of motion testing, and various applicable maneuvers. (See Barbara Silverstein, *Evaluation of Upper Extremity and Low Back*, Selected Bibliography.)

(1) Based on the severity of symptoms and physical signs, the OHN or other health care provider should decide whether to initiate conservative treatment and/or to refer promptly to a physician for further evaluation. For example, an employee experiencing pain with a positive physical sign, such as positive Tinel's, Phalen's, or Finkelstein's tests, should be referred for physician evaluation. (See Exhibits 2 and 3 of this Section.)

(2) If mild symptoms and no physical signs are present, conservative treatment is recommended. Examples include the following:

- Applying heat or cold. Ice is used to treat overuse strains and muscle/tendon disorders for relief of pain and swelling, thus allowing more mobility. Ice decreases the inflammation associated with CTDs even if no overt signs of inflammation (redness, warmth, or swelling) are present. The use of ice may be inappropriate for Raynaud's disease (vibration syndrome), rheumatoid arthritis, and diabetic conditions. Heat treatments should be used only for muscle strains where no physical signs of inflammation are present. (See Putz-Anderson, p. 125, Selected Bibliography.)

- Nonsteroidal anti-inflammatory agents. These agents may be helpful in reducing inflammation and pain. Examples of these types of agents include aspirin and ibuprofen.

- Special exercise. If active exercises are utilized for employees with CTDs, they should be administered under the supervision of the OHN or physical therapist. If these active exercises are performed improperly, they may aggravate the existing condition. (See Putz-Anderson, p. 126, Selected Bibliography.)

- Splints. A splint may be used to immobilize movement of the muscles, tendons, and nerves. Splints should not be used during working activities unless it has been determined by the OHN and ergonomist that no wrist deviation or bending is performed on the job. Splinting can result in a weakening of the muscle, loss of normal range of motion due to inactivity, or even greater stress on the area if activities are carried out while wearing the splint.

b. *Followup Assessment After Two Days.* (1) If the condition has resolved, reinforce good work practices and encourage the employee to return to the health facility if there are problems.

(2) If the condition has improved but is not resolved, continue the above treatment for approximately 2 days and reevaluate.

(3) If the condition is unchanged or worse, check compliance with the prescribed treatment and perform a screening examination. (See also section above, "Screening Assessment," for screening examination.)

- If the screening examination is positive, or if the condition is worse, refer the worker to the company physician, and seek reassignment of the employee to a light or restricted duty position.

- If the screening examination is negative for physical signs, but the condition is unchanged, continue conservative treatment.

(4) A job reassignment must be chosen with knowledge of whether the new task will require the use of the injured tendons, or place pressure on the injured nerves. Inappropriate job reassignment can continue to injure the inflamed tendon or nerve, which can result in permanent symptoms or disability. The appropriate light duty job can be selected from the list maintained by the health care provider.

Restricted or light duty jobs are one of the most helpful treatments for CTDs. These jobs, if properly selected, allow the worker to perform while continuing to ensure recovery. Some CTDs require weeks (or months, in rare cases) of reduced activity to allow for complete recovery.

c. *Followup Assessment After Six Days.* (1) After about 6 days, if the condition has now resolved, reinforce good work practices and encourage the employee to return to the health facility with problems.

(2) If the condition has improved but is not resolved, continue the above treatment for approximately 2 more days and reevaluate.

(3) If the condition is unchanged or worse, check compliance with prescribed treatment and perform a screening examination. If the screening examination is positive, refer the worker to the company physician.

d. *Followup After Eight Days.* (1) If, after about 8 days, the condition has now resolved, reinforce good work practices and encourage the employee to return to the health facility with problems.

(2) If the condition has not resolved within approximately 8 days, refer to the company physician automatically.

e. *Other Considerations.* (1) If an employee misses a scheduled reevaluation, the health care provider should contact the employee to assess the condition within approximately 5 days of the last presentation.

(2) The referring physicians or health care providers should be furnished with a written description of the ergonomic characteristics of the job of the worker who is being referred.

(3) Surgery. Recommendations for surgery should be referred for a second opinion.

If surgery is performed, an appropriate amount of time off work is essential to allow healing to occur and prevent recurrence of symptoms. The number of days off work will depend on each worker's individual response and should agree with the recommendations of the treating physician; however, this typically involves from 6 to 12 weeks recovery after carpal tunnel surgery.

(4) Return to Work. A physical evaluation of the worker after time away from work, to assess work capabilities, should be performed to ensure appropriate job placement.

When an employee returns to work after time off, after an operation, or to rest an inflamed tendon, liga-

ment, or nerve, there must be a reconditioning of the healing muscle-tendon groups. (See the guidance on "Conditioning Period Followup" in III. C. 1.b.) Consideration should be given to permanently reassigning the worker to an available job with the lowest risk of developing CTDs.

(5) The effectiveness of Vitamin B-6 and hot wax for treatment of CTDs has not been established. The use of Vitamin B-6, anti-inflammatory medications such as aspirin, hot wax, constrictive wrist wraps, and a variety of exercise programs have been advocated as effective methods for preventing work-related musculoskeletal disorders of the upper extremity. *NIOSH and OSHA, however, are unaware of any scientifically valid research that establishes the effectiveness of these interventions*. Exercises that involve stressful motions or an extreme range of motions or that reduce rest periods may actually be harmful.

(6) Every attempt to evaluate, treat, or follow up a worker with complaints of a CTD should be documented by the servicing health care provider in the individual employee medical record.

11. Recordkeeping—OSHA Recordkeeping Forms

The Occupational Safety and Health Act and recordkeeping regulations in *Title 29 Code of Federal Regulations* (CFR) 1904 provide specific recording requirements that comprise the framework of the occupational safety and health recording system. The Bureau of Labor Statistics (BLS) has issued guidelines that provide official Agency interpretations concerning the recordkeeping and reporting of occupational injuries and illnesses. These guidelines, U.S. Department of Labor, BLS: *Recordkeeping Guidelines for Occupational Injuries and Illnesses*, September 1986 (or later editions as published), provide supplemental instructions for the OSHA recordkeeping forms (OSHA Forms 200, 101, and 200-S) and should be available in every plant health care facility. Since health care providers often provide information for OSHA logs, they should be aware of recordkeeping requirements and participate in fulfilling them.

a. *Occupational Illnesses. Under the OSH Act, all work-related illnesses must be recorded on the OSHA-200 form, even if the condition is in an early stage of development.* Diagnosis of these conditions may be made by a physician, registered nurse, or by a person who, by training or experience, is capable of making such a determination. If the condition is "diagnosed or recognized" as work-related, the case must be entered on the OSHA-200 form within 6 workdays after detection.

Most conditions classified as CTDs will be recorded on the OSHA-200 form as an occupational illness under the "7f" column, which are "disorders associated with repeated trauma." These are disorders caused, aggravated, or precipitated by repeated motion, vibration, or pressure.

In order to be recordable, the following criteria must be met:

(1) **The illnesses must be work related.** This means that exposure at work either caused or contributed to the onset of symptoms or aggravated existing symptoms to the point that they meet OSHA recordability criteria. Simply stated, unless the illness was caused solely by a non-work-related event or exposure off-premises, the case is presumed to be work related. Examples of work tasks or working conditions that are likely to elicit a work-related CTD are as follows:

- Repetitive and/or prolonged physical activities.
- Forceful exertions, usually with the hands (including tools requiring pinching or gripping).
- Awkward postures of the upper body, including reaching above the shoulders or behind the back, and angulation of the wrists to perform tasks.
- Localized contact areas between the work or work station and the worker's body; i.e., contact with surfaces or edges.
- Excessive vibration from power tools.
- Cold temperatures.

(2) **A CTD must exist.** There must be either physical findings, OR subjective symptoms and resulting action. Namely, there must be either:

- At least one physical finding (e.g., positive Tinel's, Phalen's, or Finkelstein's test; or swelling, redness, or deformity; or loss of motion); OR
- At least one subjective symptom (e.g., pain, numbness, tingling, aching, stiffness, or burning), and at least one of the following:

(i) medical treatment (including self-administered treatment when made available to employees by their employer), (ii) lost workdays (includes restricted work activity); or (iii) transfer/rotation to another job.

(3) **If the above criteria are met, then a CTD illness exists that must be recorded on the OSHA-200 form.**

EXAMPLE. A production line employee reports to the health unit with complaints of pain and numbness in the hand and wrist. The employee is given aspirin and, after a followup visit with no change in symptoms, is reassigned to a restricted duty job. Even though there are no positive physical signs, the case is recordable because work activity was restricted.

b. *Occupational Injuries*. Injuries are caused by instantaneous events in the work environment. To keep recordkeeping determinations as simple and equitable as possible, back cases are classified as injuries even though some back conditions may be triggered by an instantaneous event and others develop as a result of repeated trauma. (See BLS *Recordkeeping Guidelines*, Selected Bibliography.)

Any occupational injury involving medical treatment, loss of consciousness, restriction of work or motion, or transfer to another job is to be recorded on the OSHA-200 form. Refer to the BLS guidelines for a definition of "medical treatment."

c. *Other Considerations*. (1) A case is considered to be complete once there is complete resolution of the signs and symptoms. After resolution of the problem, if signs or symptoms recur, a new case is established and thus must be recorded on the OSHA-200 form as such. Furthermore, failure of the worker to return for care after 30 days indicates symptom resolution. Any visit to a health care provider for similar complaints after the 30-day interval implies reinjury or reexposure to a workplace hazard and would represent a new case.

(2) It is essential that required data, including job identification, be consistently, fully, and accurately recorded on the OSHA-200 form. "Job identification" will include the appropriate job title for "Occupation" and the appropriate organizational unit for "Department" on the OSHA-200.

(3) OSHA recognizes that when an effective ergonomics program is implemented and occupational illnesses and injuries are recorded properly on the OSHA-200 form, the plant's total annual number of CTDs may increase. When engineering and administrative controls are put into place, however, these numbers should gradually decrease.

(4) Health care providers and others should contact the BLS Regional Office or participating State agency serving their area with questions regarding OSHA recordkeeping. Refer to the BLS guidelines (or the list at the end of these guidelines) for addresses and telephone numbers of Regional Offices.

12. Monitor Trends

a. Health care providers should periodically (e.g., quarterly) review health care facility sign-in logs, OSHA-200 forms, and individual employee medical records to monitor trends for CTDs in the plant. This ongoing analysis should be made in addition to the "symptoms survey" (described previously in this Section) to monitor trends continuously and to substantiate the information obtained in the annual symptoms survey. The analysis should be done by department, job title, work area, etc. (See also Section III. A., "Worksite Analysis Program.")

b. The information gathered from the annual symptoms survey will help to identify areas or jobs where potential CTD problems exist. This information may be shared with anyone in the plant, since employees' personal identifiers are not solicited. The analysis of medical records (e.g., sign-in logs and individual employee medical records) may reveal areas or jobs of concern, but it may also identify individual workers who require further followup. The information gathered while analyzing medical records will be of a confidential nature; thus care must be exercised to protect the individual employee's privacy.

c. The information gained from the CTD trend analysis and symptoms survey will help determine the effectiveness of the various programs initiated to decrease CTDs in the plant.

Exhibit 1

Symptoms Survey Checklist

Symptoms Survey: Ergonomics Program

DATE____/____/____

Plant Dept# Job # Job Name

Shift Supervisor Hours worked/week ____years____months Time on THIS job

Other jobs you have done in the last year (for more than 2 weeks)

Dept Job # Job Name ____months____weeks Time on THIS job

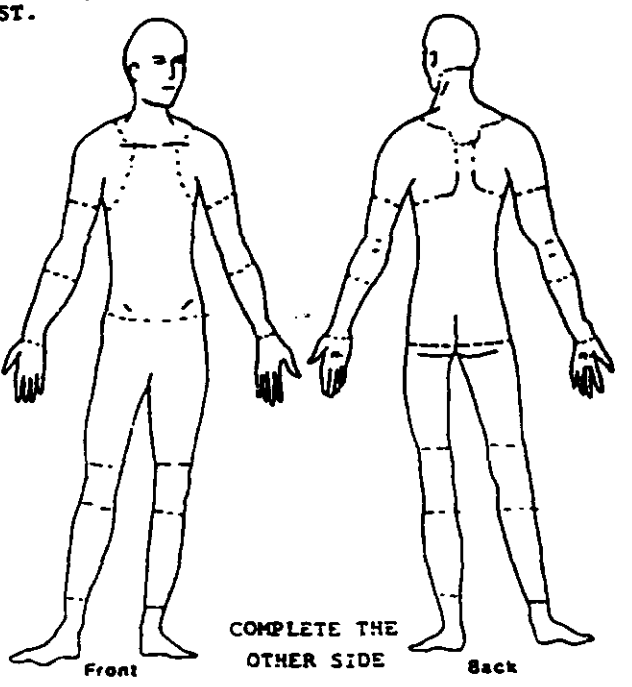
Dept Job # Job Name ____months____weeks Time on THIS job

(If more than 2 jobs, include those you worked on the most

Have you had any pain or discomfort during the last year?

1) Yes____ 2) No____ (If NO, stop here)

If YES, carefully shade in the area of the drawing which bothers you the MOST.



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(Complete a separate page for each area that bothers you)

Check Area: Neck__ Shoulder__ Elbow/Forearm __ Hand/Wrist__ Fingers__
Upper Back__ Low Back__ Thigh/Knee__ Low Leg__ Ankle/Foot__

1. Please put a check by the word(s) that best describe your problem

___1) Aching ___5) Numbness(asleep) ___9) Tingling
___2) Burning ___6) Pain ___10) Weakness
___3) Cramping ___7) Swelling ___11) Other
___4) Loss of Color ___8) Stiffness

2. When did you first notice the problem? _____(month)_____(year)

3. How long does each episode last? (Mark an X along the line)

1 hour 1 day 1 week 1 month 6 months
_____/_____/_____/_____/_____/_____

4. How many separate episodes have you had in the last year? _____

5. What do you think caused the problem_____

_____

6. Have you had this problem in the last 7 days? 1) Yes___ 2) No___

7. How would you rate this problem (mark an X on the line)

NOW
_____
None Unbearable

When it was the WORST
_____
None Unbearable

8. Have you had medical treatment for this problem? 1)Yes___2)No___

8a. If NO, why not_____

8b. If YES, where did you receive treatment?
1. Company Medical_____ Times in past year____
2. Personal doctor_____ Times in past year____
3. Other_____ Times in past year____

8c. If YES, did the treatment help? 1)Yes___ 2)No___

9. How much time have you lost in the last year because of this problem? _____days

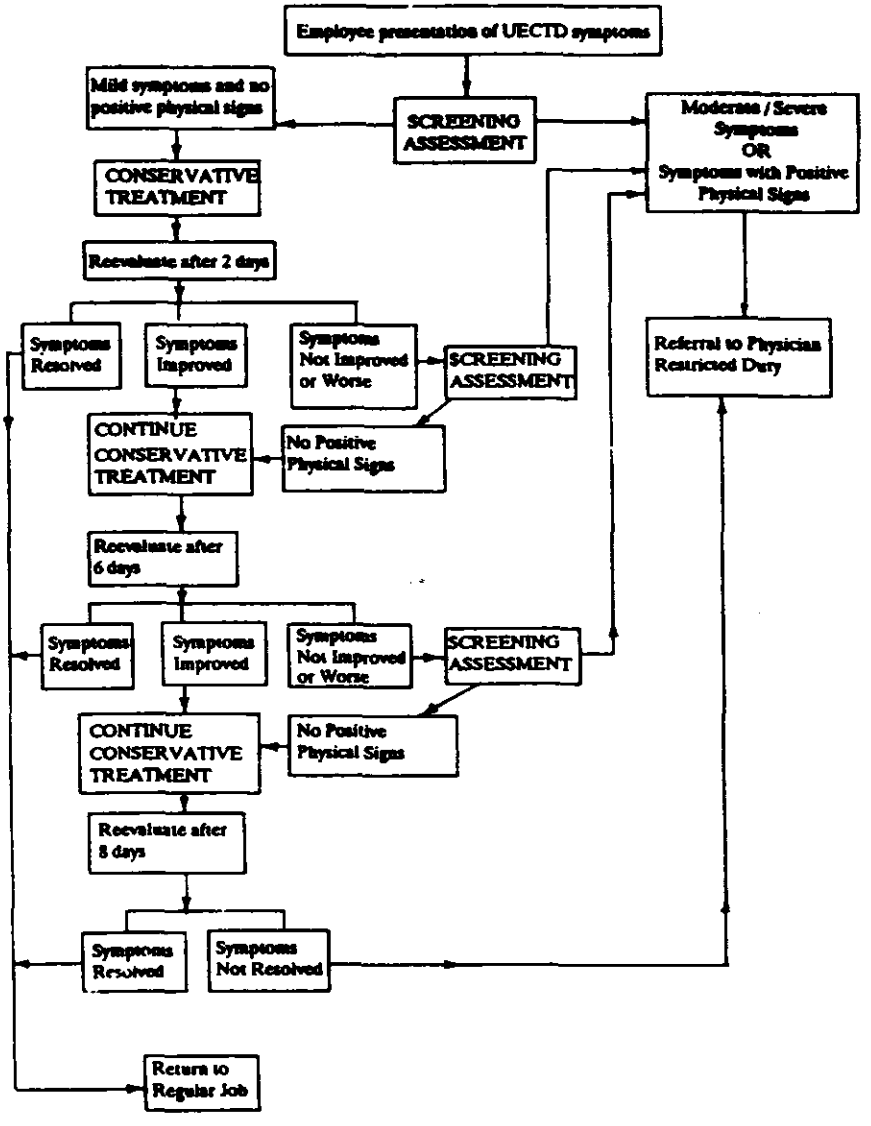
10. How many days in the last year were you on restricted or light duty because of this problem? _____days

11. Please comment on what you think would improve your symptoms

Exhibit 2

Screening Tests

Positive Tinel's sign:	Gentle tapping over the median nerve at the wrist resulting in pain, tingling, or numbness in the median nerve distribution.
Positive Finkelstein's test:	Ulnar deviation of the hand with the thumb flexed against the palm and the finger flexed over the thumb. Severe pain results at the radial styloid due to stretching of the abductor pollicus longus and extensor pollicis brevis.
Positive Phalen's test:	Unforced, complete flexion of the wrist for 60 seconds resulting in pain, numbness, or tingling in the median nerve distribution.

Exhibit 3

Upper Extremity (UE) Cumulative Trauma Disorders (CTDs) Algorithm