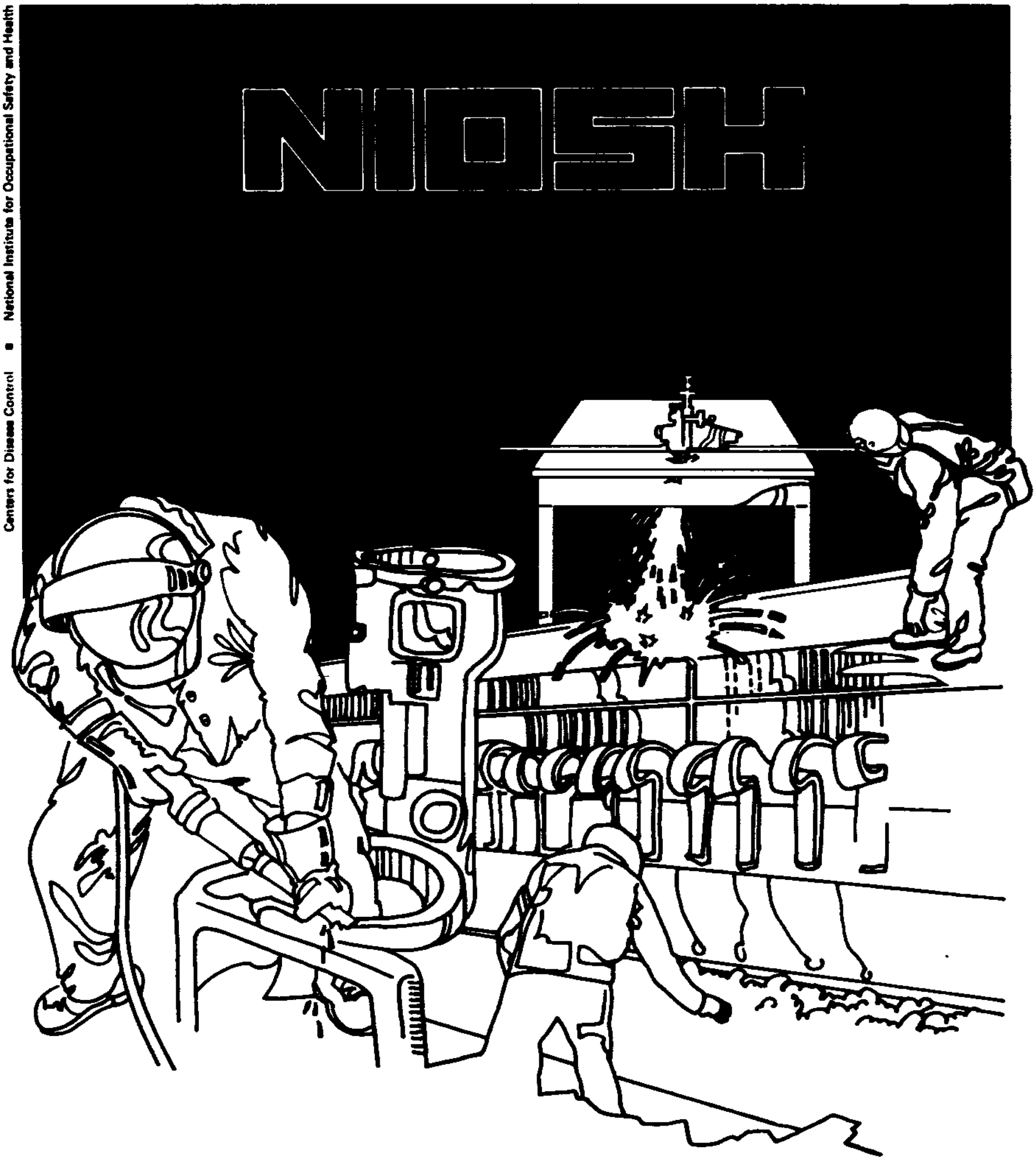
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



# Health Hazard Evaluation Report

HETA 88-384-2062
YORKTOWNE, INC.
MIFFLINBURG, PENNSYLVANIA

## PREFACE

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

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

HETA 88-384-2062
AUGUST 1990
YORKTOWNE, INC.
MIFFLINBURG, PENNSYLVANIA

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## I. SUMMARY

A Health Hazard Evaluation at Yorktowne, Inc., a cabinet manufacturing company in Mifflinburg, Pennsylvania, was conducted at the request of company management. The technical assistance was in response to the company's perception of a high incidence of musculoskeletal disorders thought to be job related. Ergonomic assessments of selected jobs in raw material handling, sawing, frame assembly, sanding and painting, cabinet assembly, and packaging/shipping departments were performed. The company log of injuries and their injury surveillance data were reviewed. Several jobs were identified that imposed potentially stressful biomechanical demands on the workers. These stressors include heavy lifting, pushing and transporting of heavy loads, fatiguing postures, repetitive lifting that involved twisting of the trunk and excessive reach distances, and repetitive motions of the trunk and upper limbs. During the period of January, 1986 to December, 1988, a total of 276 injuries were OSHA reportable injuries as noted in the company injury log for the Mifflinburg facility. Of these, 135 (49%) were related to lacerations, sprains/strains (other than back), bursitis, tendonitis or arm numbness in the upper extremities, 58 (21%) were back sprains/strains, and less than 10% each for foot/ankle, lower extremity, neck/head, and eye injuries.

Seventy percent (70%) of the injuries sustained by the workers at Mifflinburg plant occurred during their first year of employment. Forty-three percent (43%) occurred within 6 months of employment and approximately 10% occurred the first day on the job.

As a result of ergonomic assessment of selected jobs, researchers from the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research concluded that manual material handling jobs, repetitive motion tasks, and the operation of saws, planers, and sanders were potentially hazardous to workers at the facility. Recommendations include providing basic safety training for new employees, moving or redesigning equipment to reduce stress during heavy lifting, pushing, and transporting of loads, and while performing repetitive motion tasks.

KEYWORDS: SIC 5712 (Cabinetmaking), musculoskeletal disorders, repetitive motion, ergonomic, lifting, cabinet making

## II. INTRODUCTION

This report summarizes observations and analysis of jobs and tasks made during a site visit by the National Institute for Occupational Safety and Health (NIOSH) under Health Hazard Evaluation Number 88-384 to Yorktowne, Inc., Mifflinburg, Pennsylvania on May 5 - 6, 1989. The site visit was conducted by a Research Physical Therapist from the NIOSH Division of Safety Research (DSR).

## III. BACKGROUND

Yorktowne, Inc. is a manufacturer of wooden kitchen cabinets. It employs approximately 450 full time workers, 425 union and 25 salaried (non-union). The 300,000 square feet facility is situated in three different structures: two relatively new buildings where rough material is prepared for cabinet assembly and one "turn of the century" three story structure with wooden floors that is used for sanding, painting, final assembly, storage, and packing/shipping operations.

Although many tasks at Yorktowne, Inc. have been automated and new workstations have been ergonomically designed, many tasks still require the workers to push, pull, lift, and carry heavy materials. A large portion of the material is manually conveyed from department to department using small manual transport trucks with steel wheels. The loaded trucks normally weigh 300-1000 pounds. In like manner, the manual material handling tasks performed by workers stacking "green" or "kiln dried" lumber require lifting/carrying 50-60 pound loads and pushing/pulling "stacking bunks" filled with kiln dried lumber. These "stacking bunks" can weigh more than 4,000 pounds. Furthermore, many of the tasks require the workers to handle these heavy loads repeatedly. These repeated motions place these workers at risk for upper extremity cumulative (repetitive) trauma disorders (CTDs) as well as musculoskeletal sprains/strains to the back.

Management at Yorktowne, Inc. voluntarily requested assistance in identifying and resolving potential hazards their employees were exposed to during their work shift. After a briefing and organizational overview by Mr. Seth G. Neuhauser, Plant Manager, a tour of the Yorktowne, Inc. plant was conducted by Mr. Craig A. Egli and Mr. Guy J. Bellis, Industrial and Safety Engineers. Mr. Egli and Mr. Bellis then presented an overview of the Yorktowne, Inc. safety and ergonomics program, and they reviewed Yorktowne's computerized injury surveillance program. Data generated from this program were analyzed by DSR to identify those jobs and tasks that were potentially hazardous to the workers. A summary of this analysis is contained in Section IV of this report.

## IV. METHODS

Following the review of injury data, a second plant tour was conducted to collect ergonomic/biomechanical data and to identify potential hazards in the workplace. The data collection and workplace analysis included videotape, 35 mm photographs, static force measurements, and structured, voluntary interviews with the workers at risk for injury. Thirty-six (36) tasks were videotaped, 17 were reviewed. These seventeen tasks represent one complete production cycle for the manufacture of a "typical" kitchen cabinet at Yorktowne, Inc. The seventeen task reviews include a task description, a list of critical job factors, and a comment on the potential for musculoskeletal and traumatic injuries in each job. Once the review was completed, a taxonomy of selected operations with respect to risk of injury was developed. This taxonomy may be found in Section V of this report.

Of these seventeen tasks, five tasks were chosen for further analysis. The five tasks were determined to be potentially hazardous by the injury data reviewed, the identification of risk factors in each job, and the discussions with employees and supervisors. Of the five tasks, three were chosen for biomechanical analysis using the NIOSH Work Practices Guide for Manual Lifting (1), the University of Michigan, 2D Static Strength Biomechanical Analysis Program (2) and two push/pull tasks were analyzed by comparing push/pull data to normative tables by Snook (1978) (3). A detailed description of the evaluations of these five tasks can be found in Section VI of this report.

Specific recommendations for reducing musculoskeletal stressors while pushing "stacking bunks", performing manual material handling (MMH) at the defect cut saw table, pushing transport trucks, and loading small and large cabinets are included in Section VI. General considerations and recommendations to reduce and/or remove potential risk factors are also noted in Section VII.

Yorktowne, Inc. injury surveillance data were reviewed for the years 1986 through 1988. The following information was used to identify tasks and employees at risk for musculoskeletal injuries in the Mifflinburg, Pennsylvania plant operated by Yorktowne, Inc.

ACCIDENTS AND LOST TIME INJURIES

| Year | Total Accidents | Lost Time Accidents | % Lost Time | # Days Lost |
|---|---|---|---|---|
| 1986 | 84 | 35 | 42% | 542 |
| 1987 | 100 | 41 | 41% | 684 |
| 1988 | 92 | 36 | 39% | 198* |
| Total | 276 | 112 | 41% | 1,424 |

*Introduction of plant first aid stations and personnel to manage minor injuries on site. (Number of first aid case treated 142)

INJURY SUMMARY INFORMATION

| Body Part Injured | Number of Injuries 1986 | 1987 | 1988 | % of Total 1986 | 1987 | 1988 |
|---|---|---|---|---|---|---|
| Hand/Finger/Shoulder | 43 | 49 | 43 | 51% | 49% | 47% |
| Back | 21 | 20 | 18 | 25% | 20% | 20% |
| Eye | 6 | 5 | 9 | 7% | 5% | 10% |
| Foot/Ankle | 6 | 9 | 9 | 7% | 9% | 10% |
| Lower Extremity | 4 | 12 | 8 | 5% | 12% | 8% |
| Neck/Head | 4 | 5 | 5 | 5% | 5% | 5% |
| TOTAL | 84 | 100 | 92 | 100% | 100% | 100% |

LENGTH OF EMPLOYMENT AT TIME OF INJURY

| Length of Employment | % of Injuries |
|---|---|
| 1st Year | 70% |
| 1st 6 Months | 43% |
| 1st Month | 16% |
| 1st Day | 10% |

Based on the review of the company injury surveillance data and injury frequency, the following occupational groups were identified for further analysis by NIOSH.

| Occupational Groups | % Injuries | Rate/100 FTEs |
|---|---|---|
| Manual Material Handlers | 35% | 7.8 |
| Machine Operators | 31% | 6.8 |
| Frame/Cabinet Assemblers | 12% | 2.7 |
| Sanders | 8% | 1.8 |
| Painters | 7% | 1.6 |
| All Others | 7% | 1.6 |

Risk factors commonly associated with these musculoskeletal injuries at the Mifflinburg plant included: (1) sprains and strains caused by sustained postures, physical exertion, lifting and carrying and sudden movements (slips/trips/falls); and (2) repetitive motion and cumulative trauma disorders (CTD) caused by high contact forces and static loading of the musculoskeletal system, extreme or awkward joint positions, repetitive finger actions, and exposure to vibration.

## V. TASK ANALYSIS

The following seventeen tasks were analyzed according to task description, critical job factors, and potential for musculoskeletal and traumatic injury. These jobs represent one full production cycle from processing of raw material through preparation, fabrication, assembly, and packing/shipping of the finished cabinets. Videotape films, 35 mm photographs, workstation measurements, and weight/force measurements were used by NIOSH researchers to develop these lists.

JOB 1: Raw Material Handling

Task Description:

-Reach for "green lumber" with both hands
-Pull lumber toward stacking bunk
-Slid lumber into stacking bunk (stacking height varies as bunk fills)
-Push loaded stacking bunk away from conveyor to fork-lift pick-up site

Critical Factors:

-Lifting at arms reach
-Pulling heavy objects while in awkward postures
-Pushing extremely heavy objects while on uneven and slick surfaces

Potential for Injury:

-CTD of wrist, shoulders, and trunk
-Low back pain from muscle sprains/strains
-Traumatic injury from slips/trips/falls
-Lacerations and contusions from contact with lumber

JOB 2: Raw Material Planing Operation

Tack Description:

-Grasping lumber with one or two hands
-Aligning lumber on conveyor
-Clearing lumber from conveyor and "feed" tray of planer

Critical Factors:

-Pinching
-Wrist flexion and extension
-Forearm supination and pronation
-Shoulder abduction and external rotation
-Walking across operating machinery
-Walking on slippery, uneven surfaces

Potential for Injury:

-CTD of wrists and shoulders
-Musculoskeletal sprains/strains of the upper extremities
-Traumatic injury from slips/trips/falls while operating equipment

JOB 3: Rough Cut (Saw) Lumber

Task Description:

-Pick-up lumber from conveyor
-Feed lumber into "rough cut" saw

Critical Factors:

-Repetitive lifting
-Sustained awkward postures
-Exposure to open saw blade

Potential for Injury:

-CTD of upper extremities
-Sprains/strains of upper extremities and low back
-Lacerations and amputations

JOB 4: Defect Cut (Saw) Line (Loaders)

Task Description:

-Sort rough cut, planed lumber
-Pinch and grasp various lengths of lumber
-Lift and carry 8', 12',and longer lengths of lumber to defect cut saws
-Cut lumber into standard lengths
-Stack lumber on defect cut saw trays

Critical Factors:

-Pinching and grasping
-Wrist flexion and extension
-Forward flexion and abduction of upper extremities
-Flexion and weight bearing on knees while squatting and crawling in wooden conveyor
-Lifting and carrying heavy loads
-Exposure to open saw blades

Potential for Injury:

-CTD of wrist/hand and upper extremities
-Sprains/strains of upper extremities and low back
-Lacerations/contusions from contact with rough cut lumber and conveyor
-Slips, trips and falls while carrying heavy loads
-Lacerations and amputations

JOB 5: Defect Cut (Saw) Line (Machine Operators)

Task Description:

-Pick-up rough lumber
-Position lumber in defect cut saw tray
-Activate the pivot mounted, open saw
-Remove "cull" from saw
-Remove usable wood from saw
-Slid lumber to stacking area

Critical Factors:

-Exposure of hands, finger, and forearms to unguarded saw blades
-Exposure to rough edges on lumber
-Pinching and grasping
-Wrist flexion and extension
-Forearm pronation and supination
-Shoulder abduction and external rotation
-Sustained forward flexion postures of the trunk and neck
-Lower extremity sustained extension and weight bearing
-Knee and hip flexion and extension with ankle dorsiflexion/plantar flexion

Potential for Injury:

-Lacerations and amputations of hands and fingers
-CTD of wrists, hands, forearms and upper extremities
-Sprains/strains of trunk, neck and low back
-Sprains/strains of lower extremities
-CTD of lower extremities

JOB 6: Stacking Operations after Defect Cut

Task Description:

-Pinching and grasping lumber during stacking operations
-Pinching and grasping stacks of lumber
-Reaching at arms length
-Lifting and carrying small stacks of lumber
-Lifting, carrying, and stacking lumber above/below wrist height
-Push/pull loaded carts to planning machines

Critical Factors:

-Pinching and grasping
-Wrist flexion and extension
-Shoulder flexion, abduction, and external rotation
-Twisting of the upper body
-Lifting and carrying unstable loads
-Pushing/pulling heavy loads

Potential for Injury:

-CTD of wrists, hands, and upper extremities
-Sprains/strains of upper extremities and back
-Slips, trips and falls
-Dropping stacks of wood on feet
-Trauma to feet/ankles from falling lumber

JOB 7: Planing Operations

Task Description:

-Lift lumber from stacks
-Reach at or above shoulder height to load planer feed mechanism
-Activate machine and monitor operations
-Perform routine maintenance on planer
-Remove planned lumber from planer
-Stack planned lumber on transport truck

Critical Factors:

-Wrist and hand flexion/extension
-Forearm supination/pronation
-Shoulder abduction, flexion, and external rotation
-Sustained awkward postures of head/neck, trunk and legs
-Exposure to foreign objects and material exiting planer at high velocity
-Sprains/strains secondary to pushing/pulling on machine levers and transport carts

Potential for Injury:

-CTD of wrists, hands, and upper extremities
-Sprains/strains to upper extremities, trunk, neck, and legs
-Lacerations and contusions of hands
-Foreign objects in eyes

JOB 8: Gluing Operation

Task Description:

-Pick-up lumber
-Align lumber
-Apply glue to edges
-Insert lumber into compression frame
-Tighten compression screws with electric driver
-Loosen compression screws with electric driver
-Lift glued panel from compression frame
-Stack glued panels on transport cart
-Push/pull transport cart to planer

Critical Factors:

-Wrist flexion and extension
-Forearm supination and pronation
-Reaching at arms length
-Exposure of hands to glue/cement
-Awkward postures of upper body and trunk
-Repeated use of electric drivers and abrupt start/stop stresses
-Repetitive lifting and carrying heavy objects
-Pushing and pulling heavy transport carts

Potential for Injury:

-CTD to wrists, hands, shoulders
-Contact dermatitis
-Sprains/strains of shoulders, neck/head, and trunk
-Repetitive motion injuries to upper extremities
-Sprains/strains secondary to sustained posture

JOB 9: Planing of Panels

Task Description:

-Lift panels from transport truck
-Place panels on machine conveyor
-Monitor planing operation
-Remove panels from machine conveyor
-Stack panels on transport cart
-Push/pull transport cart to assembly area

Critical Factors:

-Pinching and grasping panels
-Lifting/carrying heavy objects
-Reaching at arms length
-Pushing/pulling heavy transport carts

Potential for Injury:

-CTD of wrists, hands, and upper extremities
-Sprains/strains of shoulders and low back

JOB 10: Cabinet Frame Assembly

Task Description:

-Pick-up framing material
-Place framing material in assemble jig
-Glue ends of framing material
-Connect ends of framing material
-Fasten framing material together with pneumatic nailer/stapler
-Remove frame assemble from jig
-Stack frame on transport cart
-Push/pull transport cart to planing or secondary assemble areas

Critical Factors:

- Finger flexion and extension while using pneumatic nailer/stapler
- Wrist flexion and extension with forearm supination and pronation
- Blunt trauma to wrists and hands during frame assemble
- Shoulder abduction and forward flexion
- Reaching at arms length
- Lifting/carrying heavy objects
- Pushing/pulling heavy transport carts

Potential for Injury:

- CTD to fingers, wrists, hands, and upper extremities
- Sprains/strains of upper extremities
- Sprains/strains to trunk and low back
- Blunt trauma to wrist and hand structures
- Foot/ankle injuries secondary to dropped/falling material

JOB 11: Sanding Operations (Machine)

Task Description:

- Lift panel or frame assembly onto sanding machine conveyor
- Monitor sanding operation
- Lift panel or frame assembly off of the sanding machine conveyor

Critical Factors:

- Pinching and grasping
- Lifting activities
- Exposure to dust and flying objects

Potential for Injury:

- CTD hands and wrists
- Sprains/strains to arms and back
- Foreign objects in eye
- Respiratory disorders secondary to dust/particulate inhalation
- Contact dermatitis

JOB 12: Defect Repair and Sanding Operations (Hand)

Task Description:

- Lift panel or frame assembly onto defect repair and sanding table
- Repair defects in frame and panel assemblies
- Allow glue/cement/filler to dry
- Use pneumatic hand sander to smooth repair sites
- Remove panel and frame assembly from table
- Stack panels and frames on transport carts
- Push/pull transport carts to painting/finishing areas

Critical Factors:

- -Pinching and grasping
- -Awkward upper extremity (hand/wrist) postures during repair and sanding operations
- -Sustained awkward trunk and head/neck postures
- -Lifting and carrying activities
- -Exposure to dust and flying objects
- -Exposure to hand tools

Potential for Injury:

- -CTD hands and wrists
- -Sprains/strains to arms and back
- -Foreign objects in eye
- -Respiratory disorders secondary to dust/particulate inhalation and exposure to glue/cement/filler
- -Contact dermatitis

JOB 13: Material Truck Transport

Task Description:

- -Push/pull transport carts
- -Move heavy transport carts across slick and/or uneven floor surfaces surfaces
- -Move heavy transport carts on/off elevator

Critical Factors:

- -Sprains/strains to musculoskeletal system
- -Slips, trips and falls

Potential for Injury:

- -Overexertion injuries
- -Sprains/strains
- -Blunt trauma secondary to falling material

JOB 14: Painting/Sanding Operations

Task Description:

- -Lift panels and frames from transport carts
- -Lower panels and frames onto paint conveyors OR
- -Place panels and frames onto suspended conveyor
- -Hand sand panels and frames to ensure paint adhesion to panel/frame
- -Remove panels and frames from conveyor lines
- -Inspect and stack panels frames on transport carts

Critical Factors:

-Pinching and grasping
-Lifting/lowering with arms
-Sustained awkward postures
-Repeated motions in the upper extremities
-Exposure to paint/lacquers
-Exposure to extremes of heat

Potential for Injury:

-CTD of wrists, hands, and upper extremities
-Sprains/strains of trunk and neck
-Overexertion due to exposures to excessive heat
-Respiratory disorders secondary to dust/particulate inhalation and exposure to vapors/fumes
-Contact dermatitis

JOB 15: Packing/Shipping of Doors, Panels & Hardware

Task Description:

-Lift doors, panels, and hardware items onto packing table
-Secure hinges and hardware on doors using electric driver
-Position items in shipping containers
-Fold and seal shipping containers using tape and pneumatic stapler
-Lift shipping containers from packing table
-Stack shipping containers onto transport carts
-Push/pull transport carts to shipping area

Critical Factors:

-Wrist flexion and extension
-Forearm supination/pronation
-Shoulder abduction, flexion, and external rotation
-Sustained awkward postures of trunk and neck
-Lifting and carrying heavy objects
-Pushing/pulling heavy carts

Potential for Injury:

-CTD of wrists, hands, and upper extremities
-CTD secondary to use of pneumatic tools
-Sprains/strains of upper extremities and trunk
-Lacerations and vibration exposures secondary to use of pneumatic stapler and electric driver

JOB 16: Final Cabinet Assembly

Task Description:

-Lift panel and frame assemblies from transport carts
-Insert panel and frame assemblies into jig
-Glue, staple, and nail panel and frame assemblies together
-Lift finished assemblies from jig
-Push/pull finished cabinet to shipping/packing conveyor
-Lift cabinets onto conveyor

Critical Factors:

-Pinching and grasping
-Wrist flexion and extension
-Forearm supination and pronation
-Reaching at or above shoulder height
-Sustained postures for trunk, shoulders and legs
-Lifting and carrying heavy objects

Potential for Injury:

-CTD of wrist, hand, and shoulder
-CTD of fingers
-Sprains and strains of upper extremities
-Sprains and strains of trunk and lower extremities
-Slips, trips and falls

JOB 17: Packing/Shipping

Task Description:

-Lift packing boxes and place over cabinets
-Turn cabinets over and close packing boxes
-Seal ends of packing boxes
-Complete shipping documents
-Remove boxes from conveyor
-Transport boxes to outgoing trucks
-Lift and stack boxes in outgoing trucks

Critical Factors:

-Repeated shoulder flexion and abduction
-Pinching and grasping
-Wrist, hand and forearm flexion and extension
-Repeated trunk flexion, extension, rotation and side bending
-Overexertion due to lifting and carrying
-Trauma to feet/ankles from falling or dropped boxes

Potential for Injury:

-CTD of upper extremities
-Sprains/strains of trunk, shoulders, and legs
-Contusions of feet/ankles
-Overexertion injuries

## VI. RESULTS AND DISCUSSION

Risk analysis for three lifting tasks and two push/pull tasks was completed. A biomechanical analysis of three of the more stressful and commonly performed lifting tasks at the Mifflinburg plant was completed using (1) the NIOSH Work Practices Guide for Manual Lifting and (2) the University of Michigan, 2-D Static Strength Prediction Program. The Action Limit (AL) and Maximum Permissible Limit (MPL) values for these three tasks were calculated and are shown in the table below.

NIOSH WORK PRACTICES GUIDE
ACTION LIMIT AND MAXIMUM PERMISSIBLE LIMIT VALUES

| Manual Material Handling (MMH) Tasks | Actual Load | AL | MPL |
|---|---|---|---|
| MMH at Defect Saw Cut Operation | 50 | 63 | 189 |
| Small Cabinet Load Tasks | | | |
| Cabinet Load (Low Height) | 50 | 39* | 117 |
| Cabinet Load (Medium Height) | 50 | 63 | 189 |
| Cabinet Load (Shoulder Height) | 50 | 59 | 178 |
| Cabinet Load (Overhead) | 50 | 54 | 162 |
| Large Cabinet Load Tasks | | | |
| Cabinet Load (Low Height) | 150 | 39** | 117*** |
| Cabinet Load (Medium Height) | 150 | 63** | 189 |
| Cabinet Load (Shoulder Height) | 150 | 59** | 178 |
| Cabinet Load (Overhead) | 150 | 54** | 162 |

Key: * Weight of Lift (50#) Exceeds Action Limit
** Weight of Lift (150#) Exceeds Action Limit
*** Weight of Lift (150#) Exceeds Maximum Permissible Limit

The low back disk compression forces at the L5-S1 disk interspace were calculated using the 2-D model and are shown in the table below. Biomechanical data used to calculate these compressive forces and a description of the Static Strength Model are found in Appendix 1.

LOW BACK COMPRESSION FORCES
(50th PERCENTILE MALE/FEMALE)

| Manual Material Handling (MMH) Tasks | L5/S1 Compression Forces (Pounds) Male | Female |
|---|---|---|
| MMH at Defect Saw Cut Operation | 353 | 305 |
| Small Cabinet Load Tasks (Weights up to 50 pounds) | | |
| Cabinet Load (Low Height) | 936(AL) | 774(AL) |
| Cabinet Load (Medium Height) | 699 | 596 |
| Cabinet Load (Shoulder Height) | 495 | 442 |
| Cabinet Load (Overhead) | 498 | 444 |
| Large Cabinet Load Tasks (Weights up to 150 pounds) | | |
| Cabinet Load (Low Height) | 1887(MPL) | 1633(MPL) |
| Cabinet Load (Medium Height) | 1274(AL) | 1086(AL) |
| Cabinet Load (Shoulder Height) | 1152(AL) | 1011(AL) |
| Cabinet Load (Overhead) | 1158(AL) | 1015(AL) |

Key: AL - Action Limit
MPL - Maximum Permissible Limit

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Action Limit (AL)
The large variability in capacities between individuals in the population indicates the need for administrative controls when conditions exceed this limit based on:

1. Musculoskeletal injury incidence and severity rates increase moderately in populations exposed to lifting conditions described by the AL.
2. A 770lb. compression force on the L5/S1 disc can be tolerated by most young, healthy workers. Such forces would be created by conditions described by the AL.
3. Metabolic rates would exceed 3.5 Kcal/minute for most individuals working above the AL.
4. Over 75% of women and over 99% of men could lift loads described by the AL.

Maximum Permissible Limit (MPL)

This limit is defined to best meet the four criteria:

1. Musculoskeletal injury rates and severity rates have been shown to increase significantly in populations when work is performed above the MPL.
2. Biomechanical compression forces on the L5/S1 disc are not tolerable over 1430 lb. in most workers. This would result from conditions above the MPL.
3. Metabolic rates would exceed 5.0 Kcal/minute for most individuals working above the MPL.
4. Only about 25% of men and less than 1% of women workers have the muscle strengths to be capable of performing work above the MPL.

Properly analyzed lifting tasks may be of three types.

1. Those tasks below the AL are believed to represent nominal risk to most industrial workplaces.
2. Those tasks between the AL and MPL are acceptable only if appropriate administrative or engineering controls are applied. Otherwise, those tasks are unacceptable.
3. Those tasks above the MPL should be viewed as unacceptable and require engineering controls.

Manual Material Handling (MMH) at the Defect Saw Cut Table

The L5/S1 compressive forces do not exceed the AL or MPL, but the repeated lifting and carrying tasks present a risk for the manual material handlers (35% of injuries or 7.8 injuries per 100 workers) to develop cumulative trauma disorders, sprains/strains to the back and lower extremities and shoulders, sustaining injuries from slips, trips, falls, and having objects fall on their feet.

Possible solutions include:

Perform a job analysis and re-evaluate the material flow from the "gang" saw cut line, onto the conveyor, and onto the defect saw cut table.

Reorganize the task to have shorter boards lifted from the conveyor line first and longer ones removed later. This would minimize the need for all manual material handlers from sorting through all the boards on the conveyor line.

Small Cabinet Load Task

Loading fifty pound cabinets that are sitting on the floor produces L5/S1 compression forces that exceed the AL. Moving these same cabinets from medium heights and above do not present a significant problem for a single lift, but if the task is repeated more than two times per minute then the risk of injury increases.

Possible solutions include:

Keep all finished cabinets on platforms or conveyors that are 18 inches above the floor.

Provide mechanical material handling devices to move and load the finished cabinets, e.g. overhead cranes.

Provide roller and rotating platforms to move the finished cabinets from shipping to packing and onto the delivery trucks.

<u>Large Cabinet Load Task</u>

Loading large, heavy (150 pound) cabinets that are sitting on the floor produces L5/S1 compression forces that exceed the MPL. Moving these same cabinets from medium heights, shoulder level, and overhead exceed the AL. Repeated lifting of these large, heavy cabinets produces significant compression forces on the L5/S1 interspace of both male and female workers. Therefore, these workers are subjected to back stressors that increase their risk for injury. The tasks that exceed the AL require administrative and/or engineering controls to reduce and/or remove the risk of injury. The tasks that exceed the MPL require engineering controls to reduce and/or remove the risk of injury.

Possible solutions include:

Provide mechanical material handling devices to move and load the finished cabinets.

Keep all finished cabinets on platforms or conveyors that are 18 inches above the floor.

Provide roller and rotating platforms to move the finished cabinets from shipping to packing and onto the delivery trucks.

An analysis of selected push/pull tasks performed at the Mifflinburg plant was completed. Direct measurements of push/pull forces (using a Chattilon force transducer) needed for one person to accomplish the work task were compared to normative data from Snook. (3)

INITIAL AND SUSTAINED PUSH FORCES (Pounds)
(50th PERCENTILE MALE)

| Push/Pull Task | Actual Init./Sust. | Max. Acceptable Init./Sust. (Snook) |
|---|---|---|
| 8' Stacking Bunk Push (Empty) | 158/119 | 114/77* |
| 8' Stacking Bunk Push (Full) | 235/176 | 114/77* |
| 12' Stacking Bunk Push (Full) | 320/240 | 114/77* |
| Over 12' Long Stacking Bunk Push (Full) | 500** | 114/77* |
| Transport Cart Push (Low Height) | 58/27 | 103/75* |
| Transport Cart Push (Medium Height) | 58/27 | 114/77* |
| Transport Cart Push (Shoulder Height) | 58/27 | 114/77* |

INITIAL AND SUSTAINED PUSH FORCES (Pounds)
(50th PERCENTILE FEMALE)

| Push/Pull Task | Actual Init./Sust. | Max. Acceptable Init./Sust. |
|---|---|---|
| 8' Stacking Bunk Push (Empty) | 158/119 | 77/55* |
| 8' Stacking Bunk Push (Full) | 235/176 | 77/55* |
| 12' Stacking Bunk Push (Full) | 320/220 | 77/55* |
| Over 12' Long Stacking Bunk Push (Full) | 500** | 77/55* |
| Transport Cart Push (Low Height) | 58/27 | 70/53* |
| Transport Cart Push (Medium Height) | 58/27 | 83/55* |
| Transport Cart Push (Shoulder Height) | 58/27 | 77/55* |

All "stacking bunk push" tasks are performed at shoulder height.

*Calculations are based on a single push every 5 minutes over a distance of 2.1 meters.

**The stacking bunks that were over 12' long could not be moved by a single person. Manual push force applied to these stacking bunks exceeded the 500 pound limit of the force measurement device.

Stacking Bunk Push Task

Pushing the empty, and fully loaded 8', 12' and longer length stacking bunks presents a potential risk for musculoskeletal injuries for both males and females. The forces needed to push these stacking bunks to the pick-up area are excessive when compared to maximum acceptable push/pull forces determined by Snook. Therefore, these tasks need administrative and engineering controls to reduce and/or remove the risk of injury.

Possible solutions include:

Installing a winch and/or pulley device to pull the stacking bunks to the pick-up area.

Consider other manual material handling equipment to minimize manual handling of these stacking bunks.

Purchase lighter stacking bunks.

Install larger wheels on the stacking bunks.

Repair the floor to improve the rolling surfaces on which stacking bunks move.

Transport Cart Push Task

Forces required to push the loaded transport cart do not exceed the normative data described by Snook for both males and females. However, considering the repetitive nature of the task and the uneven floor surfaces in the plant, the peak forces exerted by the workers on the carts may exceed Snook's acceptable values and increase their risk of injury.

Possible solutions include:

Fabricate permanent handles that are at or above knuckle height. (Approximately 36 inches from the floor.)

Purchase transport carts with larger diameter wheels. (Approximately 12-18 inches in diameter.)

Ensure that all transport carts are well maintained and wheel bearings are lubricated.

Eliminate uneven floor surfaces in the plant.

## VII. SUGGESTIONS & RECOMMENDATIONS

In general, all tasks that require bending down (trunk flexion) while lifting, lowering, pushing, and pulling should be eliminated through job design and/or redesign. Also, all tasks that are of high frequency and require forceful exertions by the upper extremities (while bending the wrist or pronating/supinating the forearm) should be redesigned since continued performance of the jobs in their current configuration may lead to cumulative trauma disorders.

These general guidelines present ergonomic considerations for minimizing or eliminating risk factors associated with sustained postures, overexertion, lifting/carrying, sudden movements, and repetitive motion or cumulative trauma disorders (CTDs). Therefore, ergonomic recommendations for job redesign are aimed at adjusting the workplace layout and requirements to better match human capabilities. At Yorktowne, Inc. the following general suggestions and recommendations are offered:

1. Provide for work station adjustability by installing work surfaces which can be individually adjusted by the worker. In general, the working height should be 1-2 inches below standing elbow height.

2. Eliminate pulling and pushing tasks over rollers or flat surfaces (by either one or two hands) by installing powered conveyors that deliver the part to place of operation.

3. Orient the materials being handled in a way that gravity may be used to assist the movement of the parts

4. Align the assembly and production lines such that horizontal and vertical positioning operations are eliminated. All material and sub-assemblies should be delivered to the place of assembly at the height that eliminates the need for lifting in general, but especially at arms reach. The part should be oriented at the height that requires minimal muscle power to position and remove the material or sub-assembly from a given machine or jig.

5. Eliminate the need for bending the trunk while lifting objects from the floor or lower than waist level, or lifting to low or high vertical positions, by installing lift tables that rotate, if possible.

6. Install mechanical fixtures that allow the transfer of material, sub-assemblies, and finished cabinets without involvement of human power.

7. Ensure that transport carts are mechanically safe and in good working order. Also standardize the transport cart corner post heights at 36 to 40 inches and fabricate these posts out of material that is other than "scrap". The use of "scrap" offers a variety of handle heights and poses the possibility of the "scrap" pieces breaking due to inherent defects in the lumber.

8. Examine the material flow in the defect saw cut line and sanding operations to eliminate non-productive and hazardous unloading and loading of material, sub-assemblies, and finished cabinets.

9. Use jigs and fixtures whenever possible to hold and orient components, re-sequence jobs to reduce repetition, automate highly repetitive operations, and allow self-pacing of work when possible.

10. Handles should be provided for as many tools as possible. They should be designed for minimal muscular effort and their center of gravity should be located close to the body to reduce fatigue. Power tools should be used to reduce the amount of human force and repetition required. When possible, the tools should be purchased which allow the wrist to remain in a neutral position during work tasks, i.e. bend the tool handle, not the worker's wrist. Keep the weight of the tool as small as possible.

11. Employees handling glue/cement/fillers and those exposed to lacquer/paint vapors or wood dust should be offered some form of chemical protective clothing such as nitrile rubber gloves and Saranex[R] and Tyvek[R] coveralls. Those employees needing respirators may consider using half or full facepiece air purifying respirator with organic vapor cartridge or canister. (NOTE: If respiratory protection is deemed necessary, a written protocol is required which includes but is not limited to provisions for medical examinations, and quantitative fit tests.)

12. Provide basic safety training during job orientation. Conduct this training before the employee begins work in the factory. Include information on body mechanics, safe lifting, care of the back/neck, machine safety and first aid measures for lacerations, contusions, and other musculoskeletal injuries.

13. Allow new employees to start at a slower rate so they can become conditioned prior to assuming full work capacity. Allow frequent rest pauses to provide relief for the most active muscles.

14. Additional safety-related information, selected references for ergonomic design texts, and ergonomic-related reference material may be found in Appendix 2.

## VIII. REFERENCES

1. National Institute for Occupational Safety and Health, Work Practices Guide for Manual Lifting, Technical Report No. 81-122, U.S. Department of Health and Human Services, Cincinnati, Ohio, 1981. (Copies of this document may be obtained by contacting the American Industrial Hygiene Association, 345 White Road, Akron, Ohio 44320 (Phone 216-873-2442).

2. 2-D Static Strength Prediction Program, Version 4.0, The Center for Ergonomics, The University of Michigan, Ann Arbor, Michigan, Nov., 1986.

3. Snook, S. The Design of Manual Handling Tasks. Ergonomics, Vol 21, No. 12, pp 963-985, 1978.

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## X. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. Yorktowne Inc.
2. OSHA, Region III
3. NIOSH, Cincinnati Region

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.

Appendix 1

## TWO DIMENSIONAL (2D) STATIC STRENGTH PREDICTION PROGRAM*
## THE CENTER FOR ERGONOMICS
## THE UNIVERSITY OF MICHIGAN

The two dimensional static strength program is based on the biomechanical and static strength capabilities of the employee in relation to the physical demands of the work environment. The program can be applied in the evaluation of the physical demands of a prescribed job and in the evaluation of proposed workplace designs and redesign prior to the actual construction or reconstruction of the workplace or task. Descriptions of the program output are provided to familiarize the reader with information derived from the ergonomic analysis of the work task.

The main program output is divided into four sections (windows). The task parameters or input window (upper left) is used to enter the task parameters that are required by the computer model. The stick figure window located in the upper right corner displays a stick figure representation of the postural parameters recorded from videotape reviews and/or direct measurements of the work task. The bottom window displays two sets of information. One, the window is divided into two smaller windows displaying strength and back compression data and two, the entire window can be used as a message of input window for the different program functions.

### TASK PARAMETERS WINDOW

The task parameter window is the rectangular area in the upper left portion of the program output form. The parameters required by the program are the task description, force parameters (load or weight of the object), anthropometry (weight, height, and percentile of population of the male and female workers performing the task), and postural data.

### STICK FIGURE WINDOW

The stick figure window is the rectangular area in the upper right portion of the program output form. The window displays a stick figure representation of the postural data. The stick figure is drawn to scale based on the male height that was selected in the anthropometry subsection of the task parameters window.

*Information adapted from Version 4.0 User's Manual for the Two Dimensional Static Strength Prediction Program, November 1986, The Center for Ergonomics, The University of Michigan.

Other important output data are also displayed in this area. An arrow is drawn showing the direction of the external force acting upon the worker's hands. This is opposite to the direction of hand movements. The horizontal distance (H) between the load and the spine is also presented here. It is measured from the midpoint between the ankles forward to the origin of the lift for male input anthropometry. Furthermore, the vertical distance (V), measured from the floor to the hands at the origin of the lift, is included. Finally, the horizontal distance from the L5/S1 disc to the hands at the origin of the load is displayed. A comprehensive explanation of the significance of these parameters can be attained from the NIOSH Work Practices Guide for Manual Lifting (1981). Copies of this document may be obtained by contacting the American Industrial Hygiene Association, 345 White Road, Akron, Ohio 44320 (Phone 216-873-2442).

In the upper right hand corner of this window a Balance Warning indicator is displayed. It is only present if the program senses that a given posture and force parameters are such as to cause the worker to fall forward or backward. Lastly, located next to the stick figure's lower leg is an Estimated Minimum Static Coefficient of Friction (COF) value. This is the estimated minimal COF value required between the worker and the floor surface.

STRENGTH PREDICTION WINDOW

The strength predictions are given in tabular and bar chart form in the lower left position of the program output form. The strength prediction window shows the predictions of the percentage (cumulative percent capable) of the adult population that would have the strength to perform the task as described by the task parameters. These predictions are given for each of the major articulations (joints) for both males and females. (The male bars are solid and the female's outlined.) Along with the percent capable an AL (Action Limit) or MPL (Maximum Permissible Limit) may be displayed. The AL and MPL are based on epidemiological, biomechanical, physiological, and psychophysical criteria.

Action Limit (AL)

The large variability in capacities between individuals in the population indicates the need for administrative controls when conditions exceed this limit based on:

1. Musculoskeletal injury incidence and severity rates increase moderately in populations exposed to lifting conditions described by the AL.
2. A 770lb. compression force on the L5/S1 disc can be tolerated by most young, healthy workers. Such forces would be created by conditions described by the AL.
3. Metabolic rates would exceed 3.5 Kcal/minute for most individuals working above the AL.
4. Over 75% of women and over 99% of men could lift loads described by the AL.

Maximum Permissible Limit (MPL)

This limit is defined to best meet the four criteria:

1. Musculoskeletal injury rates and severity rates have been shown to increase significantly in populations when work is performed above the MPL.
2. Biomechanical compression forces on the L5/S1 disc are not tolerable over 1430 lb. in most workers. This would result from conditions above the MPL.
3. Metabolic rates would exceed 5.0 Kcal/minute for most individuals working above the MPL.
4. Only about 25% of men and less than 1% of women workers have the muscle strengths to be capable of performing work above the MPL.

Properly analyzed lifting tasks may be of three types.

1. Those tasks below the AL are believed to represent nominal risk to most industrial workplaces.
2. Those tasks between the AL and MPL are acceptable only if appropriate administrative or engineering controls are applied. Otherwise, those tasks are unacceptable.
3. Those tasks above the MPL should be viewed as unacceptable and require engineering controls.

BACK COMPRESSION WINDOW

Back compression predictions are given in bar chart form in the lower right portion of the program output form. The predictions are made at the disc between the fifth lumbar and first sacral vertebra (L5/S1) with moment arms for the Erector Spinae muscles and Rectus Abdominals muscles being calculated as a function of body weight. The back compression window shows the predictions for both males and females. The back compression predictions are compared to the Action Limit (AL=770 lbs) and the Maximum Permissible Limit (MPL=1430 lbs) set forth in the NIOSH Work Practices Guide for Manual Lifting. Tasks between the AL and MPL are unacceptable without administrative or engineering controls. If engineering controls are infeasible for these tasks, then careful selection and training of employees must be made according to NIOSH to ensure that only those persons capable of performing the tasks are selected.

MESSAGE WINDOW

The lower third of the program output form is also used as a message window to display instructions.

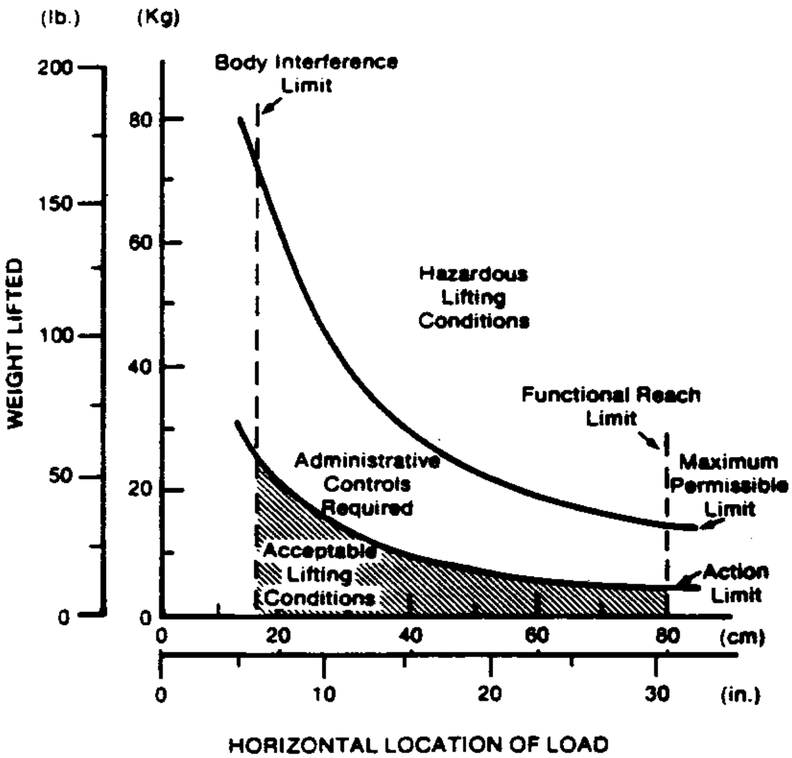
The remainder of the program output forms, pages two through four, contain biomechanical analysis data used to calculate the information summarized on page one of the output form.

## Appendix 2

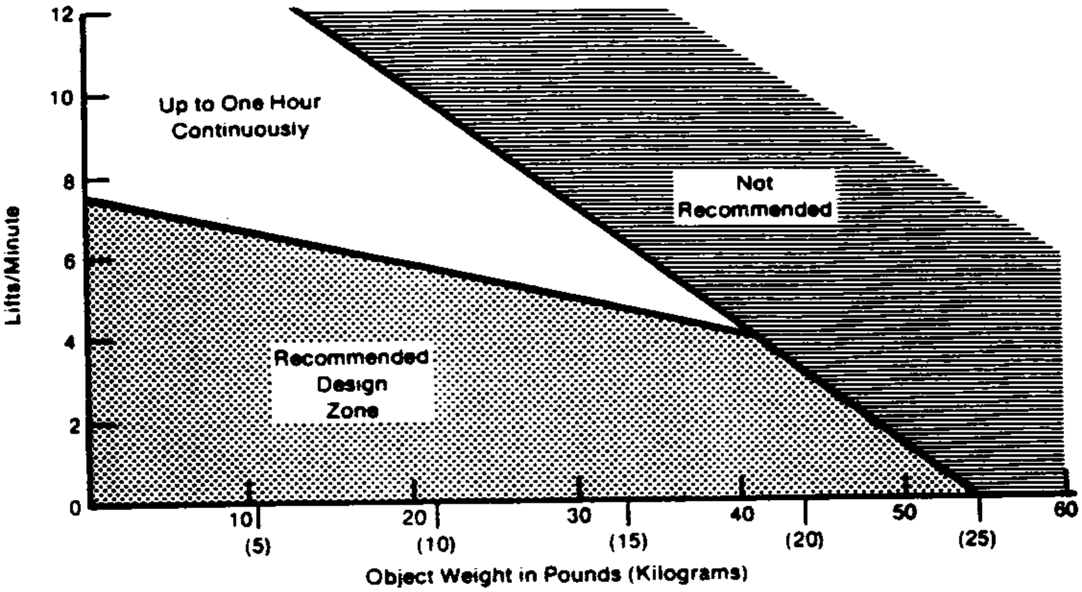
## GUIDELINES FOR MANUAL MATERIAL HANDLING AND REPETITIVE LIFTING

| Force Conditions | Maximum Force for Design Pounds | Newtons |
|---|---|---|
| Whole Body Standing | | |
| Forward Push, Truck Handling | | |
| Initial Force | 50 | 220 |
| Sustained for 1 Minute | 25 | 110 |
| Emergency Stop | 80 | 355 |
| Pull In, Waist Level | 55 | 245 |
| Pull Up from Floor Level | 125 | 555 |
| Pull Up from 20 inches (51 cm) Height | 70 | 310 |
| Kneeling | 40 | 180 |
| Upper Body, Standing | | |
| Pull Up, Waist Height | 55 | 245 |
| Pull Up, Shoulder Height, Arms Extended | 30 | 135 |
| Boost Up, Shoulder Height | 60 | 265 |
| Pull Down from Overhead | 100 | 445 |
| Push Down, Waist Level | 75 | 335 |
| Lateral Push Across Body | 15 | 65 |
| Seated | | |
| Forward Push, Waist Height | | |
| Near | 30 | 135 |
| Arms Extended | 25 | 110 |
| Pull Upward, Elbow Height | 25 | 110 |
| Pull In, Waist Height, Near | 20 | 90 |
| Lateral Push Overhead | 10 | 45 |
| Lateral or Transverse Push Across Body | 20 | 90 |
| Foot Pedal Activiation | 90 | 400 |

**Maximum Force Application Recommendations.** Data on the maximum static force levels for design of handling tasks is summarized for different muscle groups. The values shown accommodate half of the female workforce and most of the male workforce. It is assumed that these forces will be exerted for only a few seconds unless otherwise noted. (Rodgers, S., (1985), Working with Backache, Periton Press, Fairport, New York, page 106.)




<u>NIOSH Manual Lifting Guidelines</u>. The weights that can be lifted at different horizontal locations in front of the ankles are shown by three zones. The Acceptable Lifting Conditions Zone is where manual handling tasks should be designed to be suitable for most people. The guidelines were developed by a committee for the National Institute for Occupational Safety and Health. (NIOSH. 1981. Work Practices Guide for Manual Lifting. DHHS/NIOSH Publication 81-122. Washington, D.C.: Government Printing Office, page 125. Copies of this document may be obtained by contacting the American Industrial Hygiene Association, 345 White Road, Akron, Ohio 44320 (Phone 216-873-2442).




<u>Guidelines for Repetitive Lifting</u>. The maximum weight limits for lifting at different frequencies are shown. For lifts less than 1 per minute the NIOSH guidelines for occasional lifts can be used. For one hour or less of continuous lifting, frequencies above 7 per minute can be handled providing the objects are not too heavy. The Recommended Design zone will be suitable for at least 50% of the women and approximately 75% of the med. Lifts in th Not Recommended zone are suitable for less than half of the workforce and are likely to be difficult for people with low back pain. (Rodgers, S., (1985), <u>Working with Backache</u>, Periton Press, Fairport, New York, page 106.)