



NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2004-0001-2937
Superior Dairy
Canton, Ohio

May 2004

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health



PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (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 (OSHA) 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 employers 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.

HETAB also provides, upon request, technical and consultative assistance 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 NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Daniel Habes and Richard Driscoll of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Eun-A Kim. Desktop publishing was performed by Robin Smith. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Jobs in an Ice Cream Cake Department

NIOSH was asked by workers who produce frozen ice cream cakes if their jobs were causing the upper extremity and low back musculoskeletal disorders they were experiencing.

What NIOSH Did

- We watched workers as they performed their jobs.
- We talked to each worker who was on duty while NIOSH was at the plant.
- We looked at the injury logs.

What NIOSH Found

- Injuries to cake line workers have increased over the last three years.
- The filler job was the most stressful. However, all of the jobs were too repetitive. Employees did not have enough rest time during their workday.
- Some tools were not well-designed for the work being done.
- The conveyor system carrying cakes from the department to the warehouse was poorly located.

What the Superior Dairy Managers Can Do

- Slow down the production rate or automate jobs as planned.
- Redesign the conveyor system so that workers can more easily move filled boxes of ice cream cakes.
- Change the design of some tools to reduce the muscle force to use them.
- Provide workers with a chance to sit while they work.
- Add utility workers to the line who can provide more frequent breaks and keep the lines running smoothly.
- Install cushioned mats on the floor for workers to stand on.

What the Superior Dairy Employees Can Do

- Report health and safety problems to the management as soon as they occur.



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Health Hazard Evaluation Report 2004-0001-2937

Superior Dairy Canton, Ohio May 2004

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SUMMARY

On October 2, 2003, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation (HHE) from three workers at Superior Dairy in Canton, Ohio. The HHE requestors noted that approximately 30 workers on the cake line in the ice cream department were experiencing tendonitis; strains to the shoulders, elbows, wrists, and fingers; and upper and lower back disorders.

During February 18-20, 2004, NIOSH investigators conducted an opening conference, attended by representatives of the management and Teamsters Local 113 (Milk and Ice Cream Drivers and Dairy Employees); a plant walkthrough; interviews with workers; review of accident and injury logs; and observation of the work tasks specified in the HHE request.

The ergonomics evaluation indicated that the jobs in the ice cream department were highly repetitive, with the filler, scraper, and packing line jobs being the most stressful to the musculoskeletal system.

Confidential interviews were conducted with all 23 dessert cake line workers (11 women and 12 men) who were present during the days of the evaluation. Musculoskeletal injury and strain were the most commonly reported health concerns. All of the women and 70% of the men described moderate to severe work-related musculoskeletal disorders ranging from intermittent wrist and shoulder pain to chronic neck shoulder and low back pain. Workers consistently mentioned that the pace of production, the lack of consistent breaks, and the use of equipment that was not specifically designed for the tasks at hand were responsible for many of their musculoskeletal disorders.

Based on observations, employee interviews, OSHA log review, and measurements taken during this HHE, NIOSH investigators conclude that workers in the ice cream cake department of Superior Dairy are experiencing a high prevalence of chronic, work-related musculoskeletal disorders of the upper extremities and back. Recommendations to reduce the risk of further injury to workers are contained in this report.

Keywords: SIC 2026 (Fluid Milk), ergonomics, upper extremity and back musculoskeletal disorders, repetitive work, Strain Index, Hand Activity Level, NIOSH lifting equation, standing operations.

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INTRODUCTION

On October 2, 2003, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation (HHE) from three workers at Superior Dairy in Canton, Ohio. The HHE request indicated that approximately 30 workers on the cake line in the ice cream department were experiencing tendonitis; strains to the shoulders, elbows, wrists, and fingers; and upper and lower back disorders. Many of these ailments were attributed to high production rates with limited opportunity for job rotation.

During February 18-20, 2004, NIOSH investigators conducted a site visit at Superior Dairy. The NIOSH team included an ergonomics specialist, an epidemiologist, and an occupational physician. The evaluation consisted of an opening conference with representatives of Superior Dairy's management and Teamsters Local 113 (Milk and Ice Cream Drivers and Dairy Employees); a plant walkthrough; interviews with all 23 workers on duty during the site visit; review of accident and injury logs; and observation of the work tasks specified in the HHE request. The closing conference took place on February 20, 2004.

BACKGROUND

Superior Dairy is a family-owned processor of milk, ice cream, and cultured dairy products. The company has been in existence since the 1920's. In recent years, the production of ice cream cakes has been a growing part of Superior Dairy's overall business. The company produces round and sheet ice cream cakes for a number of customers, but its two main accounts are Dairy Queen (DQ[®]) and Carvel[®]. Overall growth in ice cream cake production has prompted management to consider automation to meet demand. Currently, ice cream cakes are produced manually by a team of 28 workers, comprised equally of men and women.

Job Description

The production portion of the cake department is made up of three main areas, the "chocolate side", the "white side", and the packing line. The layout is similar for both the Carvel and DQ cakes, but there are some production differences. On the DQ chocolate side, there are four workers standing at a stainless steel table, two on each side. The height of the table is set at 37 inches. The process begins with a worker placing a stainless steel mold onto a cardboard base, which is passed across the table to the filler. The filler, who operates a vertically-oriented continuous-flow hose, dispenses ice cream into the mold and passes it to the right. The filler maneuvers the hose by means of a metal handle attached to the end of the hose. The handle, which is about one inch in diameter, isolates the filler's hand from the cold ice cream flowing out of the hose. The next two workers, who stand opposite each other next to the filler workers, place preformed chocolate crunch layers onto the ice cream mold and transfer the cakes into a tunnel which freezes them. These workers return the molds to the first worker. The crunch fillers have to remove the layers from a clear plastic package before placing them onto the cake. A utility worker supplies the line with packages of crunch layer. The main difference between the Carvel and DQ cakes on the chocolate side is that there is no crunch layer for Carvel, but there are additional workers who assemble and place a cardboard collar on the Carvel cakes, which is not done for DQ.

A moving conveyor propels the cakes through the freeze tunnel, delivering them to the "white side." The worker at the end of the freeze tunnel receives another mold from an adjacent worker, places it on the cake, pours chocolate crunch on top of the cake, and places it on a moving conveyor situated in front. This worker either stands or sits on a plastic bucket. The conveyor, which moves perpendicular to the opening of the freeze tunnel, delivers the cakes to another filler. This filler dispenses vanilla ice cream into the mold through an ice cream hose held in the right hand, and then pushes the cake across the conveyor belt to two opposite-facing workers

standing at a stainless steel table oriented perpendicular to the conveyor. One of these workers uses a stainless steel spatula to scrape the excess ice cream from the mold. The blade of the spatula is about three inches wide and a one foot long with a handle on one end and a rounded tip at the other. Some workers scrape while holding the spatula with one hand and others use both hands. When Carvel cakes are produced, the scraper reaches across the moving conveyor and places the excess ice cream into a mold which has yet to reach the filler. When DQ cakes are in production, the scraper drags the excess ice cream toward them and diverts it into a funnel located at the edge of the table. The funnel delivers the ice cream to a pump which returns it to the main ice cream mixer. During Carvel cake production the funnel is not used. If there is a disruption in the flow of cakes coming from the chocolate side, the excess ice cream is captured in large stainless steel buckets, and then hand carried to and dumped into the ice cream mixer, which is located a few steps from the main production line.

After the cakes are scraped, a worker standing across the conveyor removes the mold and delivers it to the worker who supplies molds to the head of the white side line. For DQ cakes, this worker transfers them to two more workers, standing opposite each other, who place them on spinning platforms and etch a pattern on the side of the cakes using a stainless steel saw-tooth comb. These final two workers slide the cakes onto a moving conveyor leading to another freeze tunnel. This second freeze tunnel, which is about 40 feet long, carries the cakes to the packing line. Carvel cakes do not require the combing operation.

There are usually two or three workers on the packing line and, when needed, additional help can be obtained from a utility worker. The first worker on the DQ line retrieves a cake from the freeze tunnel, assembles and attaches a cardboard collar around the perimeter of the cake, and positions it on the conveyor which leads to the wrapper. The wrapper guides the cake through a machine which applies a shrink wrap and then the cake is delivered to the packer. The packer assembles a box and fills it

with cakes. A cardboard spacer is placed between layers of cakes, and when filled, the box is pushed through a closing machine which seals the top and bottom flaps shut. During Carvel cake packing there is no shrink wrap but, rather, the box is lined with a plastic bag before cakes are placed in it. After the box is sealed, the packer places it on a conveyor which takes it to the warehouse for shipping. The conveyor from which the full box is lifted is 33 inches in height.

The conveyor that the boxes are placed on ascends as it moves from the production floor to the warehouse. As such, the height at which the box is placed depends on the point of the conveyor that the packer places it. In addition, there is another conveyor which runs parallel to the transport conveyor that the packer must reach over to place the filled ice cream boxes. When DQ cakes are produced, the packing conveyor ends at the high point of the transport conveyor, just as it enters the warehouse. At this point, there is a motor in addition to the parallel conveyor that the packer must reach over to place the filled box. When Carvel cakes are produced, the packing conveyor ends in the middle of the room, about 20 feet from the transport conveyor. In this instance, the packer must carry the filled box to the transport conveyor, but can place it on a lower point of the conveyor. During DQ production, the packer is able to place the box on a lower point of the conveyor and not reach over the motor, but he would have to walk backwards to that lower point. This practice was not observed during the NIOSH visit.

Task Variables

At the time of the NIOSH site visit, workers in the ice cream department were on 10-hour shifts, five days per week. This schedule allows two days off per week, but they are usually not consecutive days. The work hours can be as few as five eight-hour days or as many as six or seven 12-hour days, depending on time of year and staffing levels. In mid- to late- spring, the ice cream department usually runs two shifts. Workers rotate every 30 minutes, primarily within their main work area: chocolate side,

white side and packing. When needed, workers on the chocolate and white side can substitute for each other. The packing area generally is staffed by full time packers and utility workers.

The Carvel products that were observed during the NIOSH evaluation were the small round and the small sheet cake. The small round is produced at a rate of 21 to 24 per minute and a full box weighs about 43 pounds. The Carvel small sheets were running at 13 to 14 per minute, with a full box Length/Width/Height (L/W/H) of 15/12/12 inches, weighing 33 pounds.

The DQ products observed were the 8-inch and the 10-inch diameter cakes. The 8-inch cake was produced at 20 per minute and a full box (L/W/H = 24/10/12) was marked at about 20 pounds, but actually weighs about 25 pounds due to an ice cream formulation change made after the boxes were printed. The mold that is used for this cake weighs about 7 pounds. The 10-inch cake was running at a rate of 14 per minute using a mold that weighs about 2 to 3 pounds. A full box (L/W/H = 24/10/12 inches) was marked at 31 pounds, but actually weighed 40 pounds owing to the same formula change as the 8-inch cake.

Over the past year, production rates for all cakes have increased. The amount of increased production varies with the type of cake, but in some cases it has been as much as 10 cakes per minute. Workers were added to the packing line to accommodate the larger number of cakes produced.

The height of the conveyor onto which packers were placing the Carvel cakes was about 65 inches. The horizontal distance between the worker and the edge of this conveyor was 24 inches due to having to reach over the parallel conveyor. The height at the top point of the conveyor where the DQ cakes were mainly placed was about 72 inches, with the horizontal distance being 34-36 inches from having to reach over the parallel conveyor and the electric motor.

For all operations, workers stood on a bare concrete or tile floor at work stations that were

typically adjusted to 37 inches in height. Most workers wore cotton and latex gloves while performing their job tasks.

METHODS

Employee Interviews

Confidential interviews were conducted with all 23 dessert cake line workers (11 women and 12 men) who were present on February 19 and 20, 2004. A total of 18 workers were interviewed on the first day, and 5 the following morning. Workers were asked to provide their age, job title, length of employment at Superior Dairy, and information about any illness or injury perceived to be the result of conditions or exposures at Superior Dairy.

Ergonomics

The ergonomics evaluation consisted of a walk-through of the department to observe the various operations as cakes were being produced. During the evaluation, table and conveyor heights and reach distances were determined using a tape measure. We talked to workers and floor supervisors to obtain information about job tasks. Recording of worker motions and movement patterns on video tape was not permitted.

EVALUATION CRITERIA

Overexertion injuries and musculoskeletal disorders, such as low back pain, tendinitis, and carpal tunnel syndrome, are often associated with job tasks that include: (1) repetitive, stereotyped movement about the joints; (2) forceful manual exertions; (3) lifting; (4) awkward and/or static work postures; (5) direct pressure on nerves and soft tissues; (6) work in cold environments; or (7) exposure to whole-body or segmental vibration.^{1,2,3,4} The risk of injury appears to increase as the intensity and duration of exposures to these factors increases and the recovery time is reduced.⁵ Although personal factors (e.g., age, gender, weight,

fitness) may affect an individual's susceptibility to overexertion injuries/disorders, studies conducted in high-risk industries show that the risk associated with personal factors is small compared to that associated with occupational exposures.⁶

In all cases, the preferred method for preventing and controlling work-related musculoskeletal disorders (WMSDs) is to design jobs, work stations, tools, and other equipment to match the physiological, anatomical, and psychological characteristics and capabilities of the worker. Under these conditions, exposures to task factors considered potentially hazardous will be reduced or eliminated.

The specific criteria used to evaluate the job tasks at Superior Dairy were the NIOSH Revised Lifting Equation (NLE), the Moore-Garg Strain Index (SI), and the American Conference of Governmental Industrial Hygienists (ACGIH) Hand Activity Level (HAL) Threshold Limit Value (TLV)

The NLE⁷ is a tool for assessing the physical demands of two-handed lifting tasks. A full description of the components of the NLE is provided in Appendix A. In brief, the equation provides a Recommended Weight Limit (RWL) and a Lifting Index (LI) for a lifting task, given certain lifting conditions. The RWL is the maximum weight that can be handled safely by almost all healthy workers in similar circumstances. The LI is the ratio of the actual load lifted to the RWL. Lifting tasks with an LI ≤ 1.0 pose little risk of low back injury for the majority of workers. Tasks with an LI > 1.0 may place an increasing number of individuals at risk of low back pain or injury. Many researchers believe that tasks with an LI > 3.0 pose a risk of back injury for most workers.

The SI⁵ is a means to assess jobs for risk of work-related musculoskeletal disorders of the distal upper extremity (hand, wrist, elbow). The SI represents the product of six multipliers that correspond to (1) intensity of exertion, (2) duration of exertion, (3) exertions per minute, (4) hand/wrist posture, (5) speed of work, and (6) duration of task per day. Preliminary tests

indicate that jobs with SI scores less than or equal to 3 are probably safe, while jobs with scores greater than or equal to 7 are probably hazardous. The calculator used to determine the SI can be seen in Appendix B.

The HAL⁸ is based on epidemiological, psychophysical, and biomechanical studies and is applied to "mono-task" jobs performed for four hours or more per day. (A mono-task job involves performing a similar set of motions or exertions repeatedly such as working on an assembly line or using a keyboard for transcription.) The HAL is based on the frequency of hand exertions and the duty cycle (distribution of work and recovery periods). The HAL can be determined with ratings by a trained observer using the scale shown in Figure 1 of Appendix C, or calculated using information on the frequency of exertions and the work/recovery ratio as described in Table 1 of Appendix C. Peak force is normalized on a scale of 0 to 10 which corresponds to 0% to 100% of the applicable population reference strength. Peak force can be determined with ratings by a trained observer, ratings using subjective exertion scales, or measured using instrumentation such as strain gauges. Peak force requirements can be normalized by dividing the force required to perform the job by the strength capability of the work population for that activity. The total exposure is characterized in terms of average hand activity level and peak hand force.

RESULTS

Employee Interviews

The average age of cake line workers was 42 years. Among participants in the interviews, men had worked an average of 10.6 years and the women had worked 4.9 years. Musculoskeletal injury and strain were the most commonly reported health concerns. One hundred percent of the women and 70% of the men described moderate to severe work-related musculoskeletal disorders ranging from intermittent wrist and shoulder pain to chronic

neck, shoulder, and low back pain. Forty percent of the workers were under a physician's care for work-related musculoskeletal disorders. Six of the men interviewed (50%) reported low back pain and related their back injury to either a work-related fall, or repetitive lifting of heavy boxes onto the overhead conveyor belt in the packing area. In addition, six women (55%) reported chronic shoulder and neck pain associated with awkward postures on the production line and the need to constantly focus their attention down at the passing ice cream cakes. Five men (42%) and eight women (73%) reported extremity pain in the arms and wrists. Eight of these workers described numbing of hands and fingers during their work shift. Three of the eleven female workers (27%) reported awakening at night with numb arms and hands.

During employee interviews, workers consistently mentioned that the pace of production, the lack of regularly occurring breaks, and the use of equipment that was not specifically designed for the tasks at hand were responsible for many of their musculoskeletal disorders.

Review of Reportable Injuries

Figure 1 presents the number of injuries recorded on the Occupational Safety and Health Administration (OSHA) Log and Summary of Occupational Injuries and Illnesses (OSHA 200 and OSHA 300 logs) for reporting years 2001 through 2003. Two injuries (both musculoskeletal) were attributed to ice cream department employees in 2001 and they represented 6% of the total injuries logged. In 2002, eight injuries (4 musculoskeletal and 4 lacerations/contusions) occurred among ice cream department employees and represented 25% of the total injuries recorded. Eleven ice cream department injuries (9 musculoskeletal and 2 lacerations) were logged in 2003 and represented 55% of the dairy's total injuries recorded. All but one of these logged injuries occurred among personnel assigned to the cake line. Figure 2 shows a comparison of the number of lost work days as a result of injury in the ice cream department to the number of lost

work days due to injury for the entire plant. Ice cream department personnel logged 18% of the lost work time injury days in 2001, 49% of the injury days in 2002, and 37% of the injury days in 2003. These injury figures show a clear rising trend in illnesses and injuries among cake line personnel and may be due in large part to increased production demands and line speed.

Ergonomics

Because there is worker rotation, each job task must be individually evaluated and the results averaged to obtain an estimate of a worker's exposure and risk of injury while performing the cake production jobs.

NIOSH Revised Lifting Equation (NLE)

As can be seen in Appendix A, the NLE is determined by measuring several task variables: the weight of the load, the horizontal and vertical positions of the hands while initiating the lift, the height to which the load is lifted, the degree of body twisting during the lift, the hand-to-load coupling, and the frequency of lifts and duration of the lifting period. For DQ, the box-marked weights and actual weights (in parentheses) are provided. Table 1 shows this information for the lifting tasks that were evaluated.

The LIs pertain only to the lifting of the sealed boxes from the packing line conveyor to the conveyor leading to the warehouse. They do not include any modification due to the walk (18-20 feet) to the warehouse conveyor that takes place during Carvel cake production. All Lifting Indexes were calculated at the origin of the lift because significant control of the boxes was not required to place them on the warehouse conveyor. Even though lifting frequencies were in the range of 2-3 per minute, duration times were considered to be short (one hour or less) because of the rotation that takes place every half hour.

The Snook psychophysical manual handling tables provide acceptable limits for some

carrying tasks.⁹ A load of 33 pounds, carried 14 feet, 3 times per minute is acceptable to 87% of males and 60% of females. Fourteen feet and 3 lifts per minute were used because they are the closest values on the tables to the actual 18 foot distance and 2 lift per minute task variables on the Carvel line. A load of 43 pounds under these same conditions is acceptable to 73% of males and 30% of females.

Strain Index (SI)

For each type of cake produced, the job tasks with the highest SI score were filler, scraper, and pack cakes into boxes (See Tables 2-5). These were the most repetitive jobs with the highest percentage of the job cycle requiring muscle exertion. Table 6 shows average SI scores assuming rotation within a given area only. Workers who rotate from the chocolate side into select jobs on the white side would have different SI scores, which could be calculated from the information contained in Tables 2-5. Even with rotation, none of the SI scores are at or below the recommended level of 7.

Hand Activity Level (HAL) Threshold Limit Value (TLV)

Most of the job tasks performed during production of the four types of cakes evaluated were above the HAL TLV, which indicates that workers, even with rotation, are at risk of developing work-related musculoskeletal disorders. In most cases, the job tasks that rated equal to or below the TLV were above the Action Limit, a level where general controls are recommended. The only job tasks that were below the Action Limit were wrapping and sealing boxes on the packing line. Results of the HAL analyses can be found in Tables 7 and 8.

Other Risk Factors

The handle on the filler was about 1 inch in diameter. Workers reported that their hands “locked on” to the grip due to holding it so tightly, and sometimes had to let go and shake their hands to relieve the fatigue and tingling they felt in their hands. Research has indicated that the grip diameter that optimizes grip force

capability while minimizing muscular fatigue is about 1.5 inches.¹⁰ Other research has indicated that workers using hand tools with grips that are loosely attached to the hand with leather or elastic bands enable rest breaks without interrupting the normal motions of the work cycle.¹¹

Workers at the end of the white side line who etch the grooves on the edges of the DQ cakes hold a small metal tool in a continuous pinch grip. Even though the applied muscular force is low while performing this task, pinch grip strength capability is only about 20% of that of a power grip (fingers wrapped around handle), and intra-wrist forces, which are a risk factor for carpal tunnel syndrome, are correspondingly greater.¹²

The worker on the white side who removes the mold, cleans it, and delivers it to the chocolate crunch fill position at the head of the line, must reach over a stainless steel sill that is part of the work table. For most molds the worker in this position easily clears the sill, but for the heavier molds, like that used in the 8-inch DQ cake (7 pounds), the sill presents a potential contact point. Likewise, the worker at the head of the line who receives the mold often has to twist at the waist to get and place the mold on an incoming cake.

During DQ production the scraper must direct the excess ice cream to a funnel located at the edge of the work table. Even though the height of this funnel has been lowered about 3 inches, it is still above the height of the table edge, requiring the worker to perform an upward sweep with the spatula, rather than a smooth motion to a destination lower than the table. The round shape of the funnel which makes tangential contact with the table edge, causes some ice cream to spill on the floor as it is dragged to the funnel.

If cakes begin to accumulate on the conveyor after chocolate crunch has been added on the white side, the filler has to hold them back with the left hand while filling them with the ice cream dispenser held in the right hand. This seemed difficult for the filler and an unnecessary

muscle exertion during one of the more stressful work tasks in the ice cream department.

In general, it appeared to be difficult to pass cakes from position to position on the stainless steel tables. Sanitized water can be used in limited amounts to decrease friction, but care needs to be taken not to saturate the cardboard base on certain cakes. When ice cream is inadvertently spilled on the table, workers must clean it up during the job cycle, so the table does not get sticky. A sticky table often makes it difficult for workers to fully pass the cakes to adjacent workers, which increases muscular effort and can increase reach distances across the metal tables.

Workers were standing on the bare floor during the production process. At one time there were mats, but they were removed because they were suspected of harboring potential contaminants to the ice cream cakes. Research indicates that floor mats are beneficial to standing workers by preventing fatigue and lower leg circulation problems.¹³

DISCUSSION

Lifting

An evaluation of the NLE concluded that the risk of having low back pain for workers who perform lifting tasks increases as the LI increases, but that this risk is not significantly greater until the LI exceeds 2.0.¹⁴ Since the highest calculated LI was 1.4, it might be concluded that the risk of injury from just lifting full boxes from the line conveyor to the warehouse conveyor is moderately elevated. The LI's were fairly low because they were calculated at the origin of the lift where the load was located at a reasonable height and could be lifted close to the body, and it was assumed that no lifting period was greater than 30 minutes, and successive lifting periods were followed by an equal non-lifting period. What the NLE could not measure was the biomechanical load on the back at the end of the lift, where the filled boxes were placed onto the conveyor over barriers,

because the workers did not have to control the box as it was thrown on the warehouse conveyor. In order to place the load on the conveyor, workers had to use arm and back muscles to propel the box. Research has indicated that forces at the low back and hip can increase by 87% to 95% when dynamic movements, such as throwing a box, are needed to perform a lifting task.¹⁵ It is likely that low back muscle forces and risk of injury to the back while loading boxes on the conveyor are much higher than the NLE could predict.

Also adding to the work load of the packers is the fact that Carvel boxes have to be carried an appreciable distance to the warehouse conveyor, and the worker performs a high-risk repetitive motion task (filling the boxes) during the time of the lifting period as measured by the SI and the HAL. Currently, there is no way to combine the results of the lifting, carrying, and repetitive motion calculations, but performing these tasks simultaneously adds to the risk of injury to these workers and provides an explanation for why 50% of the men interviewed reported low back pain that was not present before they began working at Superior Dairy.

SI and HAL

As is evident by direct observation and verified by the SI and HAL, the main risk factor for the development of work-related musculoskeletal disorders among these jobs is the production rate. The SI results indicate that task frequency, duration of exertion within a task cycle (no rest between cycles) and long work days combine to yield values that are difficult to interpret due to their magnitude. The SI was developed by applying the criteria to 25 jobs in a pork processing plant, with the range of SI scores from 1 to 81, with an average of 29.⁸ Several jobs in the ice cream cake department were higher than these values both in peak and average score by work area. One popular job analysis method by Rodgers, which evaluates the hazard level of a job based on intensity and duration of muscular exertions within a cycle, weighed against the amount of elapsed time between successive exertions, suggests that jobs

with task frequencies greater than 15 per minute not be evaluated and instead be automatically assigned a high priority for change.¹⁶ The production rate for most of the jobs in the cake department exceeds 15 per minute.

Unless these jobs are slowed down, or more workers are added to the lines, the best intervention strategy is to automate, as is currently planned. However, because the task factors comprising the SI and the HAL are inter-related, modest reductions in line speed could significantly reduce the SI and HAL scores, and hence the risk of injury. If the line speed is reduced, the duration of the exertion (which is fixed) would comprise a lower percentage of the task cycle, which would increase the rest time between successive exertions and the efforts per minute would be reduced. The highest SI scores for each product line occurred on the filler job, which tended to skew the average SI for the whole line. As an example, if the production rate was reduced from 24 to 19 cakes per minute on the Carvel small round cake, the SI for the filler job would be reduced from 122 to 27. This is still well above the upper limit of 7, but the SI of other jobs on the line would decrease as well, and the average of all jobs which all workers perform would be lower, possibly reducing the risk of injury.

CONCLUSIONS

1. Jobs in the cake department at Superior Dairy are highly repetitive and account for the high injury rates to the upper extremity and back as reported by the workers and indicated on the OSHA logs. The filler, scraper, and packing jobs pose the greatest risk of injury to the workers and, if slowed down, the overall risk of work-related musculoskeletal disorders could be reduced.

2. Among cake line workers, the number and percentage of musculoskeletal disorders have increased as production rates have increased in the department.

3. Changes in tool and work station design and the addition of workplace component, such as

chairs and cushioned mats to stand on, could reduce worker discomfort and lower the risk of injury.

4. Worker complaints and injuries will continue unless the physical content of work tasks is reduced.

RECOMMENDATIONS

As mentioned throughout this report, production rates at Superior Dairy are excessive and should be lowered or jobs should be automated. The following recommendations are offered as a means of lessening the biomechanical load on workers by adding staff or through modification of other job-related components used by the workers.

1. Install a conveyor system for transporting cakes from the production area to the warehouse that eliminates the need to carry boxes appreciable distances and placing them at heights above 70 inches and 36 inches from the body. An ideal system would automatically carry the filled boxes to the warehouse as they exit the box sealing machine.

2. Increase the diameter of the grip on the ice cream filler machines to about 1.5 inches to reduce hand fatigue and muscle force while maneuvering the filler. This should be done on the chocolate and white sides and can be accomplished by replacing the grip or adding a sleeve to the existing grip. In either case, the grip should be made of a resilient material which does not conduct heat or cold.

3. Remove the vertical sill that the mold supplier on the white side must reach over to deliver molds to the head of the line on the white side. This sill presents a possible contact point for the worker in this position.

4. Lower the funnel used on the DQ line to below the edge of the table to eliminate the upward motion needed to direct the ice cream into it. A rectangular rather than round shape would also prevent ice cream from falling to the floor.

5. For this same position, add a handle to the open end of the scraper tool so that workers who scrape with two hands can use a power grip on each end instead of a pinch grip on the open end.

6. Add a handle to the comb-like tool used to apply the grooves on the DQ cakes to eliminate the pinch grip needed to grasp and maneuver it.

8. Provide sit/stand chairs or lean bars for work positions that can be performed either sitting or standing.

9. Install mats to stand on for all positions on the chocolate, white, and packing lines. These mats should be resilient and water proof and meet Food and Drug Administration (FDA) standards for use in food producing plants, and should have mitered edges to avoid tripping hazards.

10. Add workers to the lines or provide more utility workers who could enable longer and/or more frequent rest breaks for workers, stock the lines with needed supplies, and clean tables when spills occur so the lines can function more smoothly.

REFERENCES

¹ Armstrong TA, Radwin RG, Hansen DJ [1986]. Repetitive trauma disorders: job evaluation and design. *Human Factors* 28(3): 325-336.

² Gerr F, Letz R, Landrigan P [1991]. Upper-extremity musculoskeletal disorders of occupational origin. *Annu Rev Publ Health* 12:543-66.

³ Rempel D, Harrison R, Barnhart S [1992]. Work-related cumulative trauma disorders of the upper extremity. *JAMA* 267(6):838-842.

⁴ NIOSH [1997]. Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related

musculoskeletal disorders of the neck, upper extremity, and low back. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, (DHHS) Publication No. 97-141.

⁵ Moore JS and Garg A [1995]. The strain index: a proposed method to analyze jobs for risk of distal upper extremity disorders. *Am Ind Hyg Assoc J* 56:443-458.

⁶ Armstrong TJ, Buckle P, Fine LJ, et al. [1993]. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. *Scand J Work Environ Health* 19:73-84.

⁷ Waters TR, Putz-Anderson V, Garg A [1994]. Applications manual for the revised NIOSH lifting equation. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Publication 94-110.

⁸ ACGIH [2004]. 2004 TLVs® and BEIs® for chemical substances, physical agents and biological exposure indices. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists.

⁹ Snook, SH and Ciriello. VM [1991]. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. *Ergonomics* 34(9): 1197-1213.

¹⁰ Ayoub MM and LoPresti P [1971]. The Determination of an Optimum Size Cylindrical Handle by Use of Electromyography. *Ergonomics* 14(4): 509-518.

¹¹ Armstrong, TJ, Foulke JA, Joseph BS and Goldstein SA. [1982]. Investigation of cumulative trauma disorders in a poultry processing plant. *Am Industr Hyg Ass J* 43: 03-116.

¹² Armstrong, TJ and Chaffin, DB [1979]. Carpal tunnel syndrome and selected personal attributes. *JOM* 21(7): 481-86.

¹³ Redfern, MS and Chaffin, DB [1995]. Influence of flooring on standing fatigue. *Human Factors* 37(3): 570-581.

¹⁴ Waters, TR, Baron, SL, Piacitelli, LA, Anderson, VP, Skov, T, Haring-Sweeney, M, Wall, DK, and Fine, LJ [1999]. Evaluation of the Revised NIOSH Lifting Equation: A Cross-Sectional Epidemiologic Study. *SPINE* 24(4): 386-395.

¹⁵ Tsuang, YH, Schipplein, OD, Trafimow, J.H. and Andersson, GBJ [1992]. Influence of body segment dynamics on loads at the lumbar spine during lifting. *Ergonomics* 35(4): 437-444.

¹⁶ Rodgers, SH [1992]. A functional job assessment technique. In *Ergonomics*, edited by Moore, JS and Garg, A, *Occupational Medicine: State of the Art Reviews* 7(4): 679-711.

Figure 1: OSHA Recordable Injuries: Number of Injuries by Year, 2001-2003

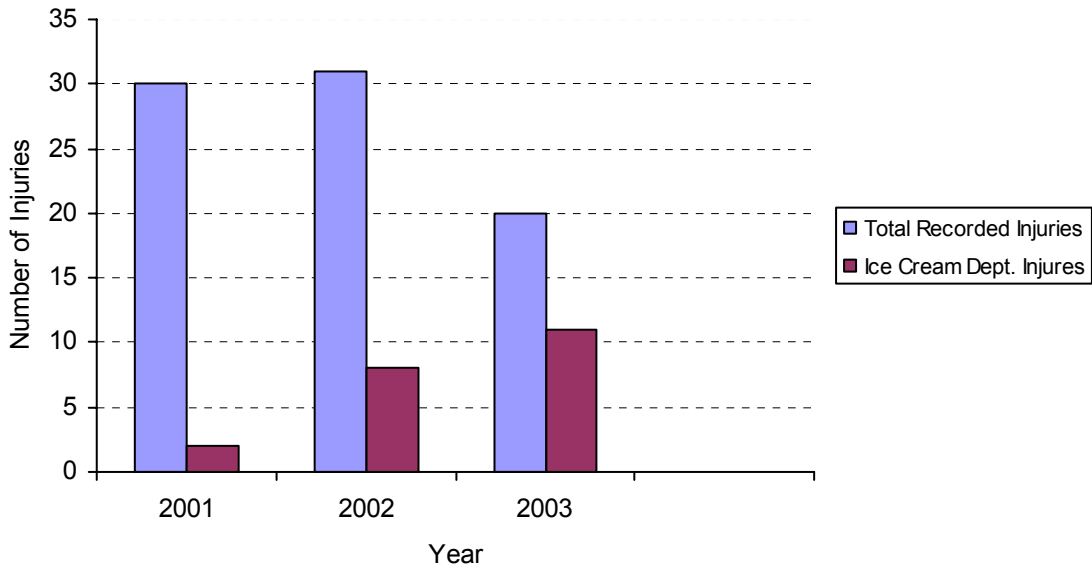
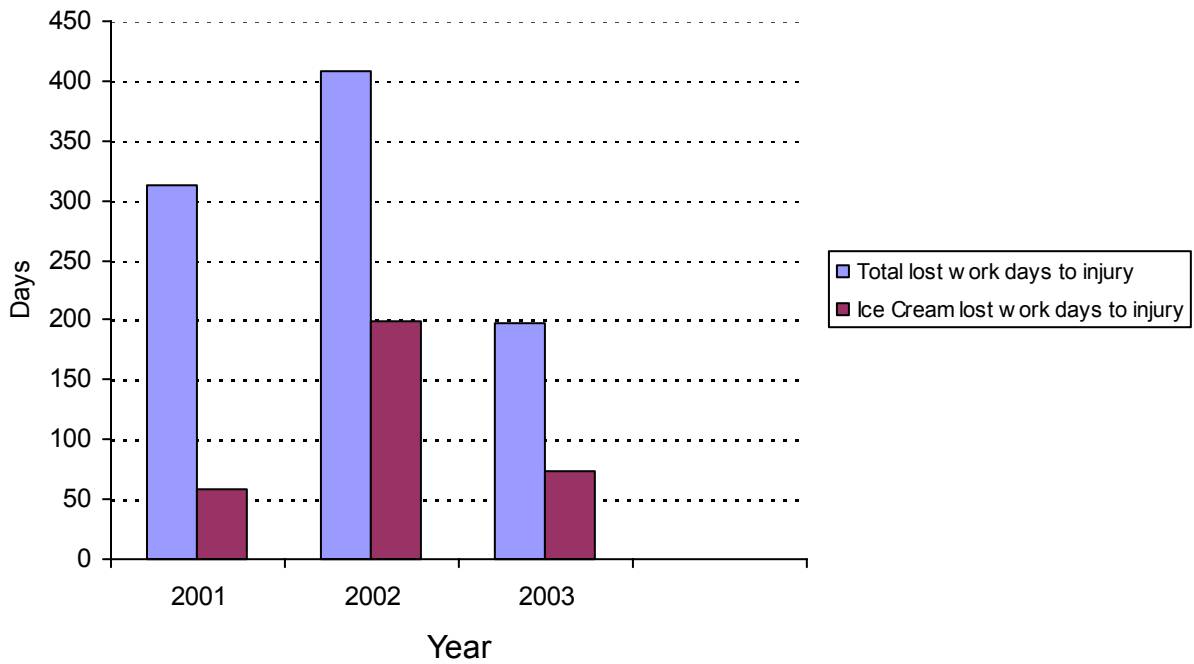


Figure 2: OSHA Recordable Injuries: Injury Lost Work Days by Year, 2001-2003



Cake Type	Box Wt. (lbs)	Hand Location		Lift Ht.	Asymmetry ⁺	Coupling ⁺⁺	Frequency	Lifting Index
		Horizontal	Vertical					
Dairy Queen 8 inch	20 (25)	13 inches	33 inches	72 inches	None	fair	3/minute, short duration	.7 (1.1)
Dairy Queen 10 inch	31 (40)	13 inches	33 inches	72 inches	None	fair	2/minute, short duration	1.0 (1.3)
Carvel Small Round	43	13 inches	33 inches	65 inches	None	fair	2/minute, short duration	1.4
Carvel Small Sheet	33	13 inches	33 inches	65 inches	None	fair	2/minute, short duration	1.1

+Asymmetry = amount of body twisting during lift
 ++Coupling: good = box has handles or hand cutouts; fair = no handles; poor = no handles, sharp edges
 () = actual box weight, in pounds

Task Name	Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Work Speed ⁺	Duration of Task	Strain Index ⁺⁺
Mold Setup - C	Light	50% - 79%	20	Good	Fast	> 8 hours	14
Filler - C	Somewhat Hard	80%-100%	20	Good	Very Fast	> 8 hours	81
Chocolate Layer - C	Somewhat Hard	30%-49%	10	Fair	Fast	> 8 hours	23
Chocolate Fill - W	Light	30% - 49%	20	Fair	Fair	> 8 hours	10
Deliver Mold - W	Hard	30% - 49%	20	Fair	Fast	> 8 hours	91
Filler - W	Hard	80%-100%	20	Good	Fast	> 8 hours	121
Scraper - W	Somewhat Hard	50%-79%	20	Good	Fast	> 8 hours	41
Del. to Spin Platform -W	Light	10%-29%	20	Good	Fast	> 8 hours	7
Apply Grooves -W	Light	80%-100%	10	Bad ‡	Fast	> 8 hours	20
Attach Collar - P	Light	50%-79%	20	Good	Fast	> 8 hours	14
Wrapper - P	Light	10%-29%	20	Good	Fair	> 8 hours	7
Box Fill - P	Somewhat Hard	50%-79%	20	Fair	Fast	> 8 hours	61

C = Chocolate Side, W = White Side, P = Packing Line
 ‡ Bad = pinch grip used by the employee
 + fair = normal speed; fast = rushed, but able to keep up; very fast = rushed and barely or unable to keep up.
 ++ Strain Index = 3 or less is safe; greater than 3 and less than or equal to 7 is elevated risk; greater than 7 is hazardous

Task Name	Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	Strain Index
Mold Setup - C	Light	50% - 79%	14	Good	Fast	> 8 hours	7
Filler - C	Hard	80%-100%	14	Good	Very Fast	> 8 hours	61
Chocolate Layer - C	Somewhat Hard	30%-49%	7	Fair	Fast	> 8 hours	15
Chocolate Fill - W	Light	30% - 49%	14	Fair	Fair	> 8 hours	5
Deliver Mold - W	Somewhat Hard	30% - 49%	14	Fair	Fast	> 8 hours	15
Filler - W	Hard	80%-100%	14	Good	Fast	> 8 hours	61
Scraper - W	Somewhat Hard	50%-79%	14	Good	Fast	> 8 hours	20
Del. to Spin Platform-W	Light	10%-29%	14	Good	Fast	> 8 hours	3
Apply Grooves -W	Light	80%-100%	7	Bad ‡	Fast	> 8 hours	14
Attach Collar - P	Light	50%-79%	14	Good	Fast	> 8 hours	7
Wrapper - P	Light	10%-29%	14	Good	Fair	> 8 hours	2
Box Fill - P	Somewhat Hard	50%-79%	14	Fair	Fast	> 8 hours	30

C = Chocolate Side, W = White Side, P = Packing Line
 ‡ Bad = pinch grip used by the employee
 + fair = normal speed; fast = rushed, but able to keep up; very fast = rushed and barely or unable to keep up.
 ++ Strain Index = 3 or less is safe; greater than 3 and less than or equal to 7 is elevated risk; greater than 7 is hazardous

Task Name	Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	Strain Index
Assemble Collar – C	Light	50% - 79%	24	Good	Fast	>8 hours	14
Mold Setup - C	Light	50%-79%	24	Good	Fast	>8 hours	14
Filler - C	Somewhat Hard	80%-100%	24	Fair	Very Fast	>8 hours	122
Remove Mold - C	Light	30% - 49%	24	Fair	Fast	>8 hours	15
Clean/Deliver Mold - C	Light	30% - 49%	24	Fair	Fast	>8 hours	15
Add Crunch - W	Light	30% - 49%	24	Fair	Fair	>8 hours	10
Filler - W	Somewhat Hard	80%-100%	24	Fair	Very Fast	>8 hours	122
Scraper – W	Somewhat Hard	50%-79%	24	Good	Fast	>8 hours	41
Direct Cake into Freeze Tunnel –W	Light	10%-29%	24	Good	Fast	>8 hours	7
Pack Cakes - P	Somewhat Hard (3 cakes at once)	50%-79%	8	Fair	Very Fast	>8 hours	27
Seal Box - P	Light	10%-29%	3	Good	Fast	>8 hours	1

C = Chocolate Side, W = White Side, P = Packing Line
⁺ fair = normal speed; fast = rushed, but able to keep up; very fast = rushed and barely or unable to keep up.
⁺⁺ Strain Index = 3 or less is safe; greater than 3 and less than or equal to 7 is elevated risk; greater than 7 is hazardous

Task Name	Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	Strain Index
Mold Setup - C	Light	50% - 79%	14	Good	Fast	> 8 hours	7
Assemble/ Place Collar - C	Light	50%-79%	14	Good	Fast	> 8 hours	7
Filler - C	Somewhat Hard	80%-100%	14	Fair	Very Fast	> 8 hours	61
Remove Mold - C	Light	50% - 79%	14	Fair	Fast	> 8 hours	10
Direct Cake to Freezer - C	Light	30% - 49%	14	Good	Fast	> 8 hours	5
Add Crunch - W	Light	30% - 49%	14	Fair	Fair	> 8 hours	10
Filler- W	Somewhat Hard	80%-100%	14	Fair	Very Fast	> 8 hours	61
Scraper - W	Somewhat Hard	50%-79%	14	Good	Fast	> 8 hours	21
Direct Cake into Freeze Tunnel - W	Light	10%-29%	14	Good	Fast	> 8 hours	3
Pack Cakes - P	Light	80%-100%	14	Fair	Very Fast	> 8 hours	20
Seal Box - P	Light	10%-29%	2	Good	Fast	> 8 hours	1

C = Chocolate Side, W = White Side, P = Packing Line
⁺ fair = normal speed; fast = rushed, but able to keep up; very fast = rushed and barely or unable to keep up.
⁺⁺ Strain Index = 3 or less is safe; greater than 3 and less than or equal to 7 is elevated risk; greater than 7 is hazardous

Activity	Chocolate Side	White Side	Packing Line
Dairy Queen 8 Inch	39	58	27
Dairy Queen 10 Inch	28	20	13
Carvel Small Round	36	45	14
Carvel Small Sheet	18	24	11

Table 7: HAL TLV for the Dairy Queen Cakes

Task Name	Dairy Queen 8 inch Cake			Dairy Queen 10 inch Cake		
	Repetition Score	Exertion Score	TLV	Repetition Score	Exertion Score	TLV
Mold Setup – C	7	3	Above	7	3	Above
Filler – C	10	6	Above	9	6	Above
Chocolate Layer - C	8	4	Above	8	4	Above
Chocolate Fill - W	5	4	Equal	5	3	Below
Deliver Mold - W	6	6	Above	6	3	Equal
Filler - W	10	6	Above	10	6	Above
Scraper - W	6	5	Above	6	5	Above
Deliver to Spin Platform W	6	2	Below	6	2	Below
Apply Grooves -W	8	2	Above	8	2	Above
Attach Collar - P	8	2	Above	8	2	Above
Wrapper - P	5	2	Below	5	2	Below
Box Fill - P	9	5	Above	8	5	Above

C = Chocolate Side, W = White Side, P = Packing Line
 HAL = Hand Activity Level

Table 8: HAL TLV for the Carvel Cakes

Task Name	Carvel Small Round Cake			Carvel Small Sheet Cake		
	Repetition Score	Exertion Score	TLV	Repetition Score	Exertion Score	TLV
Assemble Collar-C	7	3	Above	6	3	Equal
Mold Setup-C	7	3	Above	6	3	Equal
Filler-C	9	6	Above	9	6	Above
Remove Mold-C	7	3	Above	6	3	Equal
Clean and Deliver Mold-C	7	3	Above	6	3	Equal
Add Crunch-W	5	4	Equal	5	4	Equal
Filler-W	9	6	Above	9	6	Above
Scraper-W	7	5	Above	7	4	Above
Direct to Freezer-W	6	2	Below	6	2	Below
Pack Cakes-P	9	5	Above	8	5	Above
Seal Box-P	5	2	Below	5	2	Below

C = Chocolate Side, W = White Side, P = Packing Line
 HAL = Hand Activity Level

APPENDIX A

The Factors Comprising the NIOSH Revised Lifting Equation (RWL)

Calculation for Recommended Weight Limit

$$RWL = LC * HM * VM * DM * AM * FM * CM$$

(* indicates multiplication.)

Recommended Weight Limit

Component	Metric	U.S. Customary
LC = Load Constant	23 kg	51 lbs
HM = Horizontal Multiplier	(25/H)	(10/H)
VM = Vertical Multiplier	(1-(.003 V-75))	(1-(.0075 V-30))
DM = Distance Multiplier	(.82+(4.5/D))	(.82+(1.8/D))
AM = Asymmetric Multiplier	(1-(.0032A))	(1-(.0032A))
FM = Frequency Multiplier		(From Table 1)
CM = Coupling Multiplier		(From Table 2)

Where:

H = Horizontal location of hands from midpoint between the ankles.
Measure at the origin and the destination of the lift (cm or in).

V = Vertical location of the hands from the floor.
Measure at the origin and destination of the lift (cm or in).

D = Vertical travel distance between the origin and the destination of the lift (cm or in).

A = Angle of asymmetry - angular displacement of the load from the sagittal plane.
Measure at the origin and destination of the lift (degrees).

F = Average frequency rate of lifting measured in lifts/min.
Duration is defined to be: < 1 hour; < 2 hours; or < 8 hours assuming appropriate recovery allowances.

Appendix A, continued

Table 1
Frequency Multiplier (FM)
NIOSH Lifting Equation

Frequency Lifts/min	Work Duration					
	≤ 1 Hour		≤ 2 Hours		≤ 8 Hours	
	V < 75	V ≥ 75	V < 75	V ≥ 75	V < 75	V ≥ 75
0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

†Values of V are in cm; 75 cm = 30 in.

Table 2
Coupling Multiplier
NIOSH Lifting Equation

Couplings	V < 75 cm (30 in)	V ≥ 75 cm (30 in)
	Coupling Multipliers	
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

APPENDIX B

Strain Index Calculator

Intensity of Exertion

- Light
- Somewhat Hard
- Hard
- Very Hard
- Near Maximal

Duration of Exertion

- < 10%
- 10% - 29%
- 30% - 49%
- 50% - 79%
- 80% - 100%

Efforts / Minute

- < 4
- 4 - 8
- 9 - 14
- 15 - 19
- > 20

Hand/Wrist Posture

- Very Good
- Good
- Fair
- Bad
- Very Bad

Speed of Work

- Very Slow
- Slow
- Fair
- Fast
- Very Fast

Duration of Task

- < 1 Hour
- 1 - 2 Hours
- 2 - 4 Hours
- 4 - 8 Hours
- > 8 Hours

Strain Index

?

Version 1.4h
October 1996
David W. Chrislip

The Calculator used to determine the Strain Index of a Work Task

Intensity of Exertion: Light = barely noticeable or relaxed effort
 Somewhat Hard = Noticeable or definite effort
 Hard = Obvious effort; unchanged facial expression
 Very Hard = Substantial effort; changes facial expression
 Near Maximal = Uses shoulder or trunk to generate force

Duration of Exertion: Duration of all exertions divided by observation time

Efforts/Minute: Number of exertions divided by observation time

Hand/Wrist Posture: Very Good = Perfectly neutral
 Good = Near neutral
 Fair = Non-neutral
 Bad = Marked Deviation
 Very Bad = Near extreme of range of motion

Speed of Work: Very Slow = Extremely relaxed pace
 Slow = "Taking one's own time"
 Fair = "Normal" speed of motion
 Fast = Rushed, but able to keep up
 Very Fast = Rushed and barely or unable to keep up

Duration of Task: Number of hours per day task is performed

APPENDIX C

The Components of the Hand Activity Level (HAL) Threshold Limit Value (TLV)

Figure 1: The TLV for reduction of work-related musculoskeletal disorders based on “hand activity” or “HAL” and normalized peak hand force. The top line depicts the TLV. The bottom line is an Action Limit for which general controls are recommended.

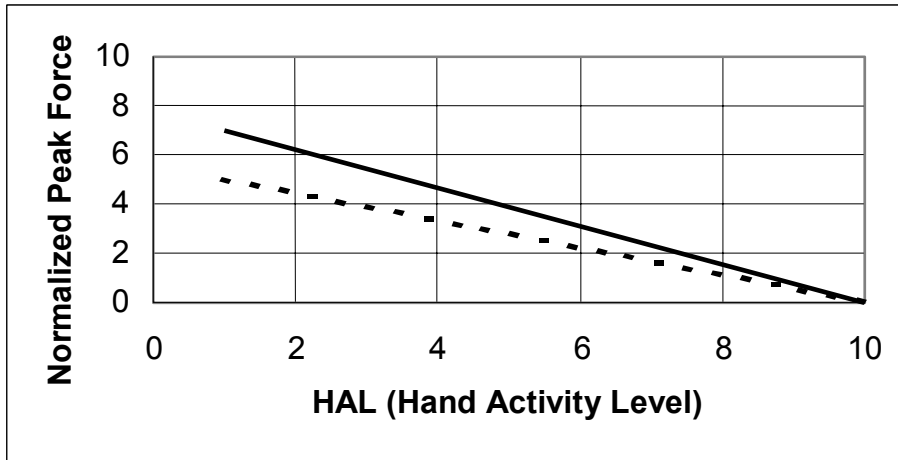


Figure 2: Hand Activity Level (0 – 10) can be rated using these repetition guidelines.

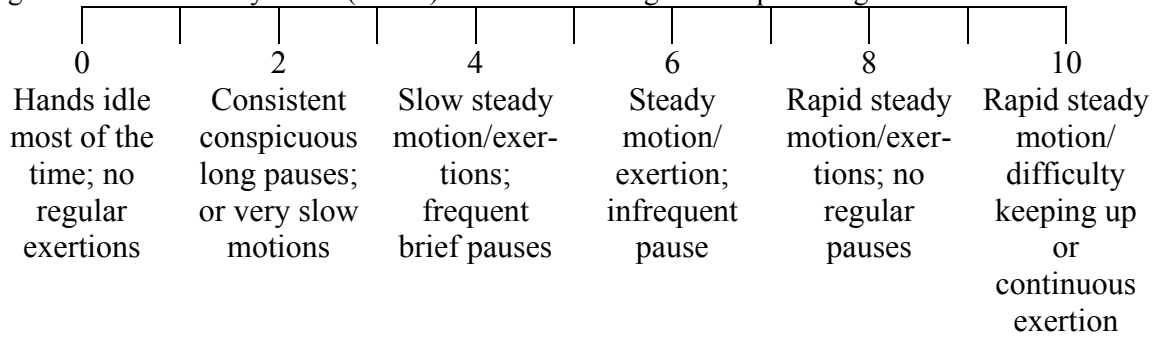
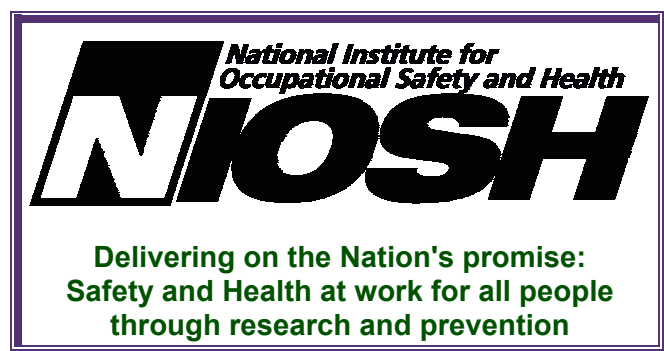


Table 1: Hand Activity Level (0 – 10) is related to exertion frequency and duty cycle (% of work cycle where force is greater than 5% of maximum)

Frequency (exertions/ second)	Period (seconds/ exertion)	Duty Cycle (%)				
		0 – 20	20 – 40	40 – 60	60 – 80	80 - 100
0.125	8.0	1	1	-	-	-
0.25	4.0	2	2	3	-	-
0.5	2.0	3	4	5	5	6
1.0	1.0	4	5	5	6	7
2.0	0.5	-	5	6	7	8

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