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I. SUMMARY

On February 24, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Chemical Workers Union (ICWU) to evaluate potential ergonomic hazards to workers involved in the production of metal and plastic containers at Bennett Industries in Peotone, Illinois. Several cases of carpal tunnel syndrome among workers who manufacture plastic containers had been reported to the union during the preceding 3 years. In response to this request, a medical and environmental investigation was conducted at the Peotone facility on June 6-7, 1989.

The ergonomic evaluation categorized the plastics container division job tasks of shrink ring operator, cutter, and handle attacher as high risk for development of cumulative trauma disorders (CTDs). Jobs in the metals division were assessed to be at low-moderate risk of development of CTDs. The questionnaire survey indicated that the prevalence of upper extremity pain is higher among workers in the plastics division compared to those in the metals division. Record review of the OSHA 200 logs and workers compensation records indicated that two job tasks (shrink ring operator and cutter) in the plastics division represented 83% of the reported CTD cases from January 1986 to June 1989 while only accounting for approximately 15% of the workforce. Thus, the medical findings support the ergonomic assessment that the job tasks of shrink ring operator and cutter have an increased risk for development of CTDs.

On the basis of this investigation, NIOSH investigators concluded that an upper extremity CTD hazard exists in the plastic containers division for the job tasks of cutter and shrink ring operator at the Peotone facility of Bennett Industries. Recommendations to prevent these CTDs are provided in Section VIII.

Keywords: SIC 3070 (miscellaneous plastic products industry), cumulative trauma disorder, carpal tunnel syndrome, plastic containers, ergonomics.

II. INTRODUCTION

On February 24, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Chemical Workers Union (ICWU) to evaluate potential ergonomic hazards to workers involved in the production of metal and plastic containers at Bennett Industries in Peotone, Illinois. Several cases of carpal tunnel syndrome among workers who manufacture plastic containers had been reported to the union during the preceding 3 years.

On June 6-7, 1989, a medical officer, an industrial engineer, and a biomechanical engineer conducted an environmental and medical survey. A walk-through survey was conducted of both the metal and plastic operations, paying particular attention to the operations involving production of plastic containers: inserting of gaskets into plastic lids, trimming of excess plastic from containers, and attaching of metal handles onto the containers.

A letter summarizing the preliminary findings of this investigation was issued on June 23, 1989.

III. BACKGROUND

A. General

Bennett Industries is involved in the manufacture of small to medium-sized plastic and metal containers (i.e. pails). The plastic and metal divisions of the plant are located in separate buildings and managed as separate entities.

At the time of our survey, Bennett Industries employed 181 people at its Peotone, Illinois facility (86 in the plastic container division, 77 in the metal container division, and 18 in general machine maintenance). The plastic container division has three 8-hour production shifts, while the metal container division has only one 8-hour production shift. Since the time our survey was conducted, the injection molding department in the plastic container division has switched from eight to twelve-hour work days. Workers in this department now alternate working three- and four-day work weeks.

Several cases of carpal tunnel syndrome had been reported to the Peotone facility management and to local union officials during the past two years. In response to employee concerns, a plant walk-through had been conducted by an ICWU industrial hygienist on February 2, 1989. This survey noted several job tasks in the production of both plastic and metal containers which required repetitive hand-wrist movements. Following this survey, a request for a NIOSH health hazard evaluation of the job tasks involved in the production of plastic and metal containers was initiated by the ICWU on February 16, 1989.

B. Job Descriptions

1. Plastics Container Division:

a. Container Operator

The main job activity of a container operator is attending to an injection molding machine that produces plastic pails. The molded pails are delivered to a standing worker by a chute located at the rear of the work station. The worker retrieves a pail from the chute with the left hand and places it on a platform while simultaneously removing another pail with the right hand from the same platform.

The latter pail is placed on a table located 90 degrees from the platform. A button is activated

with the right hand, causing the platform to spin. A heat treatment is applied to the spinning pail which readies it for a later silk screening operation. During the heat treatment, the worker "snaps" a metal handle on the pail which was previously removed from the platform. The completed pail is then stacked on the work table. Once ten pails are stacked, the worker carries the stack to the palletizing area, which is located a short distance from the main work area. There is enough room on the work table for about three stacks of ten pails. A two-cavity mold container operator completes about 218 pails per hour.

b. Cover Operator (Automated)

Molded container covers are delivered at table height to a worker by a conveyor located at the end of an injection molding machine. The worker can either stand or sit while performing the job. Circular-shaped gaskets called shrink rings are located to the left of the worker on the same table to which the covers are delivered. The worker picks up a shrink ring with the left hand and loosely places it around the inside perimeter of a cover held by the right hand. The assembly is then placed on a circular fixture located in front of the worker. The worker actuates the fixture with a two-handed control mechanism which causes the fixture to spin and, with hardware attached to the fixture, secures the gasket to the cover. The completed cover assembly is then stacked on a table located to the right of the worker. A material handler periodically removes stacked covers from the work place. A cover operator assigned to a four-cavity mold completes about 450 covers per hour.

c. Cover Operator (Manual)

A seated worker receives molded covers from a conveyor located to the right of the work table. Gaskets are located to the left of the worker. The worker picks up a gasket with the left hand and loosely secures it on the cover, which the worker places in front of him/her with the right hand. The gasket is secured to the cover by sliding a straight tool around the perimeter of the cover. At the time of the plant walk-through, the worker was receiving green, gray, and orange covers. Only the green and gray covers required gaskets. The orange lids were stacked to the left of the worker immediately after the worker received them from the conveyor. The finished gray and green lids were stacked in front of the workplace and removed by anotherworker, who was performing a different operation on the covers. On a typical day, a worker in this area handles 190 covers per hour.

d. Shrink Operator

Pails formed on certain molds will not achieve a uniform diameter opening if left to harden naturally. These pails are forced onto a shrink ring of a set diameter through which cold water circulates. This operation accelerates the hardening of the pail opening and assures that the proper diameter is obtained.

Standing workers receive molded pails from a conveyor located in front of them. A pail is removed from the conveyor and forced with both hands onto one of eight shrink rings located in the work area. The worker then trips a lever to release a pail that was already on one of the shrink rings. This pail is taken to a spin fixture on which the heat treating operation is performed (previously described). The worker then removes the pail, snaps a metal handle onto the pail, stacks it in the workplace, and returns to the conveyor which delivers freshly-molded pails. At the time of the plant walk-through, there were two workers receiving two sizes of pails from the same conveyor. These are the two remaining pails produced by the company that require the shrink operation. Occasionally, one worker has to perform the shrink operation on both sizes of pails for short periods of time. Each worker would normally process 119 pails per hour performing the shrink operation.

A worker will typically spend one-third of the workday on this operation. The remaining two-thirds of the day are spent on other container operator positions. The maximum amount of time spent on this job would be four hours per day, assuming a 12-hour shift.

e. Silkscreening

This job is comprised of three rotating positions: the line feeder, the silkscreener, and the inspector/stacker. Rotation takes place every 15 minutes throughout the day. The rate of work for this job is 500-600 pails per hour.

(1) Line Feeder

The line feeder places pails from stacks onto a moving roller conveyor. The conveyor sends the pails through a flame treatment (readying them for decorating) to the silk screener.

(2) Silkscreener

The silkscreener receives pails from the conveyor at about waist height. A pail is removed from the conveyor with the right hand and is placed on a round fixture with both hands. The fixture is horizontally-oriented, at about the worker's shoulder height. The worker actuates a floor-mounted pedal with the right foot, which causes the fixture to rotate counterclockwise and then clockwise to apply the silkscreened label. The completed pail is removed from the fixture and placed on a belt conveyor located to the left of the worker.

(3) Inspector/Stacker

This worker receives decorated pails from the silkscreener. Each pail is inspected and, when necessary, touched up by hand. Finished pails are placed on a roller conveyor located near the worker and rejects are stacked in the work place.

f. Offset Silkscreening

Two jobs were studied in this area: the offset silkscreen operation, and the handle attachment operation ("snapping handles").

(1) Silkscreen

Stacks of undecorated pails are located behind the standing worker. The worker brings a number of pails into the immediate work area and places them one by one on the mandril of the automatic silkscreening machine. The rotating action of the machine positions the pails for silkscreening and transfers them to a conveyor that leads to the handle snapping area.

(2) Handle Attaching

Decorated pails received from the silkscreen machine are removed from the conveyor with either the right or left hand, and a metal handle (stacked in the work area) is "snapped" into place on the pail. Completed pails are stacked five high on the work table, and then placed on another conveyor which leads to the inspection/packing area. The worker can sit or stand while performing this operation. The three workers in this area produce 950 pails per hour.

Generally, there is one worker operating the silkscreen machine and two workers snapping handles. These workers rotate positions every 15 minutes.

g. Pallet Tray Making

Pallet trays are shallow boxes (about four inches deep) that are placed at the bottom and top of stacks of pails. Bands of steel secured around the pallet trays comprise the package in which most pallets of pails are shipped. These boxes are assembled by packers/inspectors, line operators, or any other personnel available when pallet trays are needed.

A standing worker places stacks of flat cardboard sheets on a large square table. The edges of the cardboard sheets are scored where they are to be folded. Using a suspended stapler, the worker fastens the corners of adjacent edges together. The cardboard sheet is rotated about the stationary work table until all four corners of the box are stapled. Typically, the worker folds the edges with both hands, holds the corners together and rotates the cardboard sheet with the left hand, and activates the stapler with the right hand. The completed tray is stacked on its side in an area adjacent to the worker. About 20-25 pallet trays are assembled by various workers per hour.

h. Blow Molding Department

Two job tasks were evaluated in the Blow Molding Department. These were cutter and line operator.

(1) Cutter

Cutters receive molded containers from machines located behind the work station. Excess flashing that accumulated during the molding operation is removed from the bottom, the handle, and the opening of each container. Containers are placed on the cutting table, and the flashing is removed by hand and through use of a knife. The containers are trimmed as needed, and then placed on a conveyor for cooling while being transported to the line operator for additional operations. Cutters rotate every hour, but only with other cutters. Two cutters attending to four molding machines will trim 72 containers/hour/cutter.

(2) Line Operator

The line operator receives containers from the cooling conveyor. Each type of container is positioned on the proper drill press where the opening is "reamed" out. The containers are then removed from the drill press and taken to another station, where chips of plastic are loosened with an air jet and removed with a vacuum cleaner. Finished parts are placed on a conveyor for transport to the next operation.

2. Metal Container Division:

a. Press Room - Stamp Lids

This job consists of three operations through which each worker rotates every half hour. During the first operation, sheets of metal are fed into a punch press by a standing worker. The metal sheets are stacked on the worker's right, and there is a bin for scrap to the left of the worker. Each sheet is large enough to yield four lids. After the first lid is stamped, the worker rotates the sheet with both hands in a clockwise direction. This rotation is continued until all four lids are stamped, and the excess metal is placed in the scrap bin. About 12,000 lids are stamped per day.

At the second operation, stamped lids, delivered by a belt conveyor to a sitting worker, are placed on a punch press which forms the edge of the lid. This operation was scheduled to be automated shortly after the time of our plant walk-through inspection.

The third worker receives lids from the second punch press operator and stacks them at the end of the work table. The lids are then transported to another work station for additional operations.

b. Stamp Holes in Lids

After a painting operation, the formed lids are delivered to a punch press operation where holes are stamped. Stacks of lids are arranged to the left of the seated operator. A lid is placed in the punch press with the left hand, and both hands are used to activate the control buttons. The lid is removed with the left hand, a gasket is placed on the hole with the right hand, and the completed lid is stacked to the right of the worker. Material handlers then remove the stack lids and deliver them to the next operation. Four hundred lids are processed per hour at this work station.

c. Packing Containers

Completed metal containers are delivered to two standing workers by a roller conveyor. The pails are taken off the conveyor with either the right or left hand and stacked on a pallet. The final height of the stacks is about 62 inches. When the pallet is filled, a third worker stacks lids on the pallet and places a cardboard tray on top and secures the pallet tightly. About 22,000 containers per day are packed in this manner.

IV. METHODS

A. Medical

The medical investigation included a review of the OSHA 200 logs (1985 to present) and Workers' Compensation files (1985 to present). Additionally, a brief confidential screening questionnaire for upper extremity disorders was given to current employees from all shifts of the metal and plastic manufacturing areas who were involved with operations requiring repetitive upper extremity motions. Information collected included a current job history and a medical history, with a focus on current or recent musculoskeletal problems involving the upper extremities or neck.

B. Ergonomic

The ergonomic evaluation included videotaping several jobs in the plastic container and metal container divisions as they were performed during the first shift of operation. These jobs had either been historically associated with cumulative trauma disorders (CTDs) of the upper extremity or appeared to involve considerable manual activity when observed during the plant walk-through inspection. All of the jobs were subsequently analyzed to determine the time to complete one full movement in the operation (cycle time), the number of movements per cycle, presence of awkward postures, and estimated muscular force requirements.

V. EVALUATION CRITERIA

Cumulative trauma disorders (CTDs) of the musculoskeletal system often occur in workers whose jobs require repetitive upper extremity exertion. These disorders can present themselves as bursitis, ganglionic cysts, musculoskeletal strain, synovitis, tendinitis, tenosynovitis, and/or numerous other specifically described musculoskeletal syndromes, including carpal tunnel syndrome. These disorders affect the nerves, tendons, and tendon sheaths of the upper extremity. Studies have shown that these disorders can be precipitated and aggravated by activities associated with repetitive exertion, particularly if completion of the tasks requires significant application of force in an awkward posture.[1-14] The postures most often associated with upper extremity CTDs are wrist extension and flexion, ulnar and radial deviation of the wrist, open-hand pinching, twisting movements of the wrist and elbow, and shoulder abduction. CTDs are considered in many cases to be work-related because these types of postures and movements are required in many manufacturing and assembly jobs in industry. Occupations for which a high incidence of CTDs have been reported include electronic components assembly, textile manufacture, small appliance manufacturing and assembling, meat processing and packing, fish filleting, and buffing and filing. What is common to all of these jobs is repetitive, stereotyped movement of the hand, arm, and wrist, coupled with varying degrees of muscular exertion. The actual incidence of CTDs among these and other industries has not yet been established, but incidences as high as 44 cases per 100 workers per year have been reported.[15]

Because occupational factors are considered to be of major importance in the development of these disorders, few non-occupational antecedents of CTDs are identified or reported. Examples of non-occupational risk factors include: hobbies and recreational activities, such as woodworking, tennis, weight lifting, knitting, and sewing. All of these pastimes impose physical demands on the musculotendinous system similar to those of the jobs mentioned above.

Carpal tunnel syndrome was initially noted as a clinical entity as early as 1895. However, not until 1947 was this median nerve disorder fully described and recognized as a syndrome in medical literature. The presently accepted clinical presentation of the syndrome includes: pain and parathesias (burning and tingling sensation) in the hand along the distribution of the affected median nerve, precipitation of similar symptoms at night while sleeping, and possible radiation of pain to other portions of the involved arm/hand .[16-20] Carpal tunnel syndrome may be associated with non-occupational factors such as acute trauma, diabetes mellitus, hormonal factors (use of oral contraceptives, pregnancy, and gynecological surgery), rheumatoid arthritis, acromegaly, wrist shape/size, congenital (at birth) defects, and gout.[21] Since a number of these conditions are unique to women, their risk of carpal tunnel syndrome may be elevated. While women have been reported to be at high risk for CTS due to occupational factors, very few studies have compared the rate of CTS in men and women performing identical jobs. Silverstein et al. found that women and men were at essentially the same risk if performing identical job activities.[22, 23]

There are several factors which may precipitate occupational cumulative trauma disorder. Among these are excessive muscular force, short length of job cycles, and high frequency of movements. One study found that workers performing jobs with force levels of 4 kilograms or more were four times as likely to develop hand/wrist CTDs as those workers whose jobs required muscular exertions of 1 kilogram or less.[24] Job tasks with cycle times lasting 30 seconds or less were found to be associated with an incidence of upper extremity CTDs three times greater than those jobs where the cycle time was greater than 30 seconds.[24] In studies reporting an increased incidence of CTDs, where the number of hand movements was recorded, the range was from 5,000 to 50,000 repetitions per day.[5, 25-33] The work activities were varied and included cutting poultry, keystroking, hand sanding/filing, and packing tea.

Because of the complexity of repetitive motion patterns, it has been difficult to define a critical frequency factor for defining a CTD risk. Recently, however, guidelines for using frequency of movement as a method for assigning risk to a repetitive task were developed and applied in a study of a meat processing and packing plant.[34] Low risk was defined as fewer than 10,000 movements per day, medium risk as 10,000 to 20,000 movements per day, and high risk as 20,000 or more movements per day. These frequency of movement criteria are intended merely as guidelines for judging the relative risk of a hand intensive job task. It is also important to note that other factors associated with the performance of a work activity, such as high levels of muscular force exerted and awkward upper extremity postures, would reduce the number of movements defining each of the above risk categories.

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

VI. RESULTS AND DISCUSSION

A. Medical

A review of the OSHA 200 logs and Workers' Compensation records disclosed 14 reported cases of carpal tunnel syndrome (CTS) from January 1986 to June 1989 (Table 1). Recorded job information for each of the reported CTS cases indicated that all of these employees had worked in the plastic containers manufacturing division. Ten of the 14 cases were workers with the job title of shrink ring operators in the open-head plastic containers production line. Three of the remaining four CTS cases were among workers known as cutters in the blow molding department. The other CTS case occurred in a worker who applies silkscreening to the plastic containers.

In addition to CTS cases, 10 other cases of upper extremity cumulative trauma disorders (including tendinitis and ganglionic cyst) were also reported from January 1986 to June 1989 (Table 1). Seven of these 10 (70%) CTD cases occurred among workers in the plastics division. Shrink ring operators represented six of these seven CTD cases in the plastics division; the other occurred in a cutter. However, the other three (30%) cases involved workers known as drum line operators in the metal containers division.

No cases of cumulative trauma disorder were reported in the OSHA 200 logs for the year 1985. During 1986, 1987, 1988, and half of 1989, however, a total of 24 cases (including CTS cases) were reported. Using company records, estimated cumulative incidence rates for CTDs over this 3-1/2 year period were 5.2 (plastics) and 1.2 (metals) per 100 person-years. One can compare these rates with data from the Bureau of Labor Statistics (BLS) 1987 Annual Report;[35] the incidence rate for disorders associated with repeated motion, vibration, or pressure (this includes CTDs) for the miscellaneous plastic products industry [Standard Industrial Code (SIC) #3070] was 0.35 per 100 full-time employees, and for the fabricated metal products industry (SIC #3410), which includes processing of metal cans and shipping containers, was 0.078 per 100 full-time employees. (The BLS incidence rate includes other disorders besides CTDs, notably hearing loss.)

Another comparison rate is from the Mayo Clinic in Rochester, Minnesota from 1961 to 1980: 0.105 cases of carpal tunnel syndrome per 100 person-years.[36] The incidence rate in the plastics container division for CTS cases alone was 4.5 per 100 full-time employees for the period described previously. Although the incidence rates for CTSs and CTDs at Bennett Industries are based on a small number of cases, comparison with other rates indicates that the facility's rates are substantially higher than what would be expected, particularly in the plastics division.

Questionnaires were completed by 95 of 107 (89%) current workers (77 in the plastics division, 21 in the metals division). The others were unavailable at the time. The prevalence of upper extremity symptoms and medical treatment for CTDs was higher among workers in the plastics division, but the differences were not statistically significant (Table 2). Further analysis of the questionnaire by job task, department, and duration of employment was attempted; however, due to small numbers of workers in various job categories or departments, and multiple job task rotation within a work shift, this information was not meaningful.

B. Ergonomic

The videotapes for each of the above jobs were analyzed to determine cycle time, number of movements per cycle, presence of awkward postures, and estimated muscular force requirements. These data are combined for purposes of assigning to each job a risk level for development of CTDs, based on a standard 8-hour shift.

On April 29, 1990, a shift change took place in the injection molding area of the Plastics Division. As of this date, workers are assigned to a 12-hour shift, three days one week and four days the next. For jobs in this department, risk levels will be presented based on the eight-hour shift that was in place at the time of the study, and for the new 12-hour shift schedule.

1. Plastics Container Division

a. Container Operator

The time and motion study for this job indicated that there were five or six movements for the right hand and three movements for the left hand per job cycle. The main ergonomic stressors associated with this task are wrist extension while activating the button on the spin table (because the button is too low), the muscular force needed to snap the handle in place, shoulder abduction while attaching the handle to the pail, and shoulder flexion while stacking the pails ten-high on the work table. Because the pail could be maneuvered while attaching the handle, wrist postures were maintained mostly in the neutral position during this portion of the operation.

The height of the table is the primary workplace factor causing shoulder flexion and abduction during this operation. The most useful function the table serves is to provide easy access to the handles. These could be kept on a hook or small extension attached to the spin fixture. This extension could also be used to stabilize the pail while the handle is snapped. If the table was removed from the work area, the palletizing area could be moved closer to the worker and the stacking of pails on the table, and subsequent transport to the pallet area could be eliminated.

The force required to snap the handle in place was judged to be medium because of the neutral wrist postures and because the warm plastic facilitates the deformation of the pail needed to position the handle. At 218 pails per hour, the range of hand movements per eight-hour day is 8,720-10,464 for the right hand and 5,232 for the left hand. Corresponding 12-hour shift movements would be 13,080-15,696 for the right hand, and 7,848 for the left hand. According to the evaluation criteria, this job is in the medium risk category for development of upper extremity CTDs, regardless of the shift length.

b. Cover Operator (Automated)

The video analysis indicated that four movements per hand were required to perform this operation. At 3,600 covers per four-cavity mold, the total movements made each day would be 14,400 per hand in an eight-hour day. The hand movement total for this job performed in a 12-hour day would be 21,600 for each hand. Muscular force needed to perform this operation is judged to be low to moderate, and the only observed deviated posture was moderate wrist extension while activating the button which controls the fixture. This job presents medium risk for the development of CTDs in an 8-hour day and high risk for a 12-hour day.

Even though there was a stool in the work place (actually several stacked pails covered with

padding), it does not appear to be possible to perform this job while sitting. It would be difficult to activate the control buttons, and the worker would not be able to stack the completed covers on the adjacent table to the height necessary. However, performing the task in a properly designed seated position would provide some variety to the worker and relief from constant standing.

c. Cover Operator (Manual)

This job required four right hand movements and one left hand movement per cover. The right hand movement made to retrieve the cover from the conveyor was low in force, while the three made to fit the ring in the groove appeared to require considerable muscular force. The tool used during the operation had a suitable handle for a power grip and could be used mostly with the wrist in the neutral position. Occasionally the worker deviated the wrist in the radial direction while repositioning the lid in preparation for the second forceful movement. Assuming that each cover requires a gasket, the number of movements per eight-hour day for this job would be 6,080 for the right hand and 1,520 for the left. Twelve-hour shift movements would be 9,120 for the right hand and 2,280 for the left. Because of the muscular force required to perform this job, the risk level for the development of CTDs is in the medium to above average category.

d. Shrink Operator

The video analysis of this job indicated that eight right-hand and six left-hand movements were required per pail. The movement patterns were approximately the same for the two different sizes of buckets. The main postural stressors were wrist extension (both hands) to force the pail onto the shrink ring, extension of the right wrist to activate the button that spins the pails, and right wrist extension and left wrist radial deviation to snap the handles in place. The muscular force required to force the pails onto the shrink ring was judged to be high, and the force to snap the handles on the pail was considered to be moderate. Other aspects of the job were judged to be low to moderate in muscular force demand.

At 119 pails per hour, a worker on this job would make 7,616 right hand movements and 5,712 left hand movements during a typical workday. Twelve-hour movement rates would be 11,424 for the right hand and 8,568 for the left hand. These are moderate repetition rates. However, the amounts of force required to place the pails on the shrink ring, and to snap the handles on the pails, pose a high risk to the worker for developing hand/wrist CTDs. The CTD risk of the workers performing this job depends on the positions to which they rotate.

e. Silkscreening

Because workers rotate through the "line feeder," "silk screener," and "inspector/stacker" operations of this job, the repetition rates and ergonomic stressors for these tasks will be presented and discussed together.

The line feeder places a bucket on the conveyor with one movement of each hand. Additional movements may be made by the worker to reposition stacks of pails delivered by a material handler, but these were not observed and are assumed to be incidental. Muscular forces required are low to moderate, and there are no deviated wrist postures associated with this job task. At 500-600 pails per hour, the range of movements for this task would be 4,000-4,800 per day for each hand.

Placing the pails on the silkscreening machine requires three right and three left hand movements. Right wrist flexion while picking the pail off the conveyor, and left hand extension while positioning the pail on the silkscreening fixture, were observed in both workers performing this aspect of the operation. One of the workers followed the action of the silkscreening machine with the left hand, a movement pattern which was judged to contribute an unnecessary stress to the worker. Force required to perform this part of the task appeared to be moderate. At 500-600 pails per hour, this task, if performed exclusively, would require 12,000-14,400 movements for each hand.

The inspector/stacker, on average, made two right hand movements and one left hand movement per piece. These figures take into account the fact that most pails are merely transferred from one conveyor to the next, with no touch-ups. For those pails where touch-up was required, it was difficult to judge the amount of force exerted. Overall forces, however, appeared to be low to moderate for this job task. At 500-600 pails per hour, this job requires 8,000-9,600 movements for the right hand and 4,000-4,800 movements for the left hand. There were no observed postural stressors for this job task.

Assuming that the three workers in this area performed each of these tasks equally throughout the day, the number of hand movements for each worker would be 8,000-9,600 for the right hand, and 6,666-8,000 for the left hand. Overall assessment of this job is low to moderate risk of developing hand/wrist CTDs.

The silkscreening department is not scheduled for 12-hour days, but increased work-hour days are a possibility if more than the usual number of injection molded pails are decorated. If this were to occur, 12-hour shift repetitions would be between 12,000 and 14,400 for the right hand and between 9,999 and 12,000 for the left hand. The assesment of this job would still be moderate risk of developing hand/wrist CTDs.

f. Offset Silkscreening

(1) Silkscreen

Loading pails onto the offset silkscreener requires two right hand movements and one or two left hand movements. The job can be performed with no postural deviations, although occasionally the observed worker flexed or extended the right wrist while positioning the pail on the machine. Muscular force required appeared to be low to moderate. At 950 pails per hour, a worker would make 15,200 right hand movements and between 7,600 and 15,200 left hand movements performing this task for eight hours. Twelve-hour shift repetitions would be 22,800 for the right hand and between 11,400 and 22,800 for the left hand. The offset silkscreening department is not scheduled for 12-hour days, but increased work-hour days are a possibility if more than the usual number of injection molded pails are decorated.

(2) Handle attaching

"Snapping handles" is an unstructured task, subject to individual style. On average, four right hand movements and three left hand movements were required to attach a handle to a pail. The main postural stressor observed was flexion of the right wrist while manipulating the pail. Muscular force exerted was difficult to estimate, but it is well known that the force needed to deform a cold pail exceeds that to deform a freshly-molded pail. The force seemed to be the main concern of the workers, and the consensus was that snapping handles in the offset area was extremely difficult. As such, muscular force was judged to be moderate to high for this job. It is important to note that only one or two movements per pail required high force levels; receiving a pail from the conveyor and stacking a finished pail in the work area are relatively low force activities.

At the time of the videotaping, the line leader was attaching handles, so there were three workers on the line instead of the normal two. Assuming that the normal rate is 475 pails per worker per hour, this job would require 15,200 right hand movements and 11,400 left hand movements if performed for eight hours. Twelve hour repetition rates would be 22,800 for the right hand and 17,100 for the left hand. The combination of force and repetition associated with this work task places the worker at a higher than average risk for developing CTDs during an eight-hour shift and a high risk of CTD development if performed for 12 hours.

The time-weighted hand movements, assuming that the two workers who snap handles rotate with the one feeding the mandril are: 15,200 for the right hand and a maximum of 12,654 for the left hand. Muscular forces would be lower because each worker would be spending one-third of the day loading pails onto the silkscreening machine. This combination still poses a higher than average risk of CTD development to the workers in this area.

g. Pallet Tray Making

Assembling one small cover box requires 16 right hand and eight left hand movements. The main postural stressors are trunk flexion, shoulder abduction, and wrist flexion (both hands) to fold the front and back edges of the box, forearm pronation to fold the sides of the box, and pinching with the left hand to hold the corners in place while stapling with the right hand. Muscular forces were judged to be moderate to high.

At the rate the worker was assembling boxes, about 1,100 could be produced in an eight-hour workday (137 per hour), representing about 18,000 right hand and 9,000 left hand movements per shift. According to the evaluation criteria, this job would present an elevated risk for the development of CTDs. However, pallet tray making is a "filler" job performed by packer/inspectors and line operators as needed, who make about 200-250 boxes per 12-hour shift. A worker could assemble the required number of boxes in less than two hours, an increase in effort level which would likely not affect the CTD risk level of the worker's normal job.

h. Blow Molding Department

(1) Cutter

At the time of the videotaping, there were two cutters attending to two machines, whereas there are normally three cutters assigned to five machines. At the rate the cutters were observed to be working, about 960 containers could be cut and trimmed per eight hour day. However, a typical cutter will normally only complete 72 pails per hour (576 per eight-hour day).

About 22-25 right hand movements are required to trim and cut one container. The left hand is used mainly to hold the container while operations are being performed with the right hand. The main postural stressors are shoulder abduction and ulnar and radial deviation of the right wrist. Because the container is manipulated several times during the operation, right-hand wrist deviations occur less than expected.

Overall muscular force requirements were judged to lie between moderate and high, with some of the operations requiring high force demands, e.g., pulling off the flashing from the container and cutting with the knife. Right hand movements per shift, based on 576 containers per day, would range between 12,672 and 14,400, which is medium according to the evaluation criteria. However, because of the muscular force requirements, this job presents a higher than normal risk of CTDs to the worker.

(2) Line Operator

At the time of the videotaping, the line operator was processing green, yellow, and white containers. Each of these is processed in the same manner, but at different drill presses. However, the video analysis indicated that processing each of the different colored containers required the same general pattern of movements and that, on average, the range was 5-6 movements for each hand. The main postural stressors were shoulder flexion to retrieve a container from the cooling conveyor and shoulder flexion to place the long-nozzle vacuum into a container opening. Wrist postures were mostly neutral during the work cycle. Muscular forces were judged to be low to moderate.

At 1,152 containers per cycle, movements would range between 5,760 and 7,056 for each hand. This job presents only a moderate risk of CTD development to the worker.

2. Metal Container Division

a. Press Room - Stamp Lids

This job requires about five movements per piece for both hands. Twelve thousand lids are stamped per day, which means that the worker handles 3,000 metal sheets in a work shift. Hand postures are neutral while performing this task, but the hands are maintained at shoulder height and the elbows are flexed during most of the job cycle. A worker performing this task exclusively during the day would be required to make 15,000 right and left hand movements. Muscular force was judged to be medium for this task. Overall impressions are that this job presents a medium risk to the worker for the development of CTDs.

It is important to note that stamping lids is the most repetitive and forceful of three rotating positions, one of which was scheduled to be automated shortly after the time of the ergonomics evaluation. The CTD risk of any one worker performing the "stamp lids" operation must be modified based on whatever rotational scheme evolved as a result of the automation which took place.

b. Stamp Holes in Lids

This job requires about three right hand and four left hand movements per job cycle. Work rate is 400 pieces per hour. A worker performing this job for eight hours would make 9,600 right hand and 12,800 left hand movements.

The most commonly occurring postural stressors were wrist extension in both hands to activate the button controlling the press, extension of the right wrist while removing lids from the press, and shoulder abduction, elbow extension, and ulnar deviation of the right hand to stack finished pieces to the right of the press machine.

Muscle forces required were judged to be medium. Occasionally, the worker struggled to separate incoming lids before placing them into the press machine, which added unnecessarily to the force demands of the task, but not enough to affect the overall force assessment. This job presents a medium risk of CTD development to the worker.

c. Packing Containers

Stacking metal containers for packing requires one movement per hand per container. At 11,000 containers per worker per day, this job would require 11,000 movements per hand during a typical day. Postural stressors included ulnar deviation and flexion of the wrist while stacking the containers in the packing area. The main postural stressor observed was reaching over the head (shoulder flexion) to stack containers 10 high. In general, the stack height would be excessive for short workers. Muscle force requirements appeared to be low to moderate, as would be the overall CTD risk of this job.

VII. CONCLUSIONS

The ergonomic evaluation categorized the plastics container division job tasks of shrink ring operator, cutter, and handle attacher as high risk for development of CTDs. The questionnaire survey indicated that the prevalence of upper extremity pain is higher among workers in the plastics division compared to those in the metals division. Record review of the OSHA 200 logs and workers compensation records indicated that two job tasks (shrink ring operator and cutter) in the plastics division represented 83% of the reported CTD cases from January 1986 to June 1989 while only accounting for 15% of the workforce. Thus, the medical findings support the ergonomic assessment that the job tasks of shrink ring operator and cutter have an increased risk for development of CTDs.

VIII. RECOMMENDATIONS

From the ergonomic evaluation, most of the job tasks studied at this plant were categorized generally as medium risk for CTD development, based on an eight-hour day. Except as noted below, no immediate action needs to be taken on these jobs, even though stressful postures and movements requiring elevated muscular force levels were noted. However, these stressors, if eliminated, could provide a means to reduce the ergonomic risk level of a job, or serve as a starting point for intervention if surveillance activities indicate that musculoskeletal problems on particular jobs had begun to develop.

The switch from 8- to 12-hour work days in the injection molding department presents a situation which is difficult to assess. Some of the jobs (as noted in the Results section) increase in risk due to the increase in repetitions over the 12-hour day. However, the repetition rates described above in the Evaluation Criteria section are based on the assumption of 8-hour work days, and a 5-day work week. Workers in the injection molding department work three- and 4-day work weeks. Therefore, we recommend that close monitoring of the workers in this department so that quick action can be taken in the case that the change in work schedule has an influence on the health of the workers.

A. Plastics Division, Container Operator

1. Reorient the button which controls the spinning table to allow for activation with a neutral wrist posture. The button could be oriented vertically at the level of the table, enlarged and padded to allow for activation with the knee, or even located on the floor to allow activation with a foot pedal.

2. Remove the table on which completed pails are stacked from the work area. This would allow for pails to be stacked near the worker and would eliminate the excessive stack heights and the need to carry stacks of pails to the palletizing area.

B. Plastics Division, Cover Operator (Automated)

1. Consider modifying the job task to allow for easy performance while sitting. This modification would require:

    a. an adjustable chair with back support;

    b. reorientation of the control buttons, or introduction of a foot pedal to control the spinning fixture; and

    c. a lower table for stacking completed covers, or a slide or chute which delivers the covers directly to the material handler.

C. Plastics Division, Cover Operator (Manual)

1. Provide the worker with a chair having back support.

D. Plastics Division, Shrink Operator

1. Eliminate through mechanical assist or automation the requirement that workers force molded pails onto the shrink rings. This aspect of the operation combines high muscular force with postural stress (wrist extension) that is not tolerable for any but the strongest workers. An interim intervention would be to identify light duty tasks that workers could rotate into after spending limited time on the shrink operation. Performance of the shrink operation should not exceed 1 hour at a time, and no more than 4 hours in a 12-hour workday.

2. Reorient control buttons on spin table as in container operator job discussed above.

3. Continue efforts to eliminate the production of pails that require the shrink operation.

E. Plastics Division, Offset Area, Attaching Handles

1. Eliminate through mechanical assist or automation the requirement that handles be attached manually to cold pails. A mechanical assist means a tool or process that aids in deforming the pail so that the handle can be easily attached. An interim or alternative intervention would be restricted time snapping handles, with light duty work assigned between rotations into this job.

F. Plastics Division, Pallet Tray Making

1. Divide the amount of time needed to perform this task (about two hours) among at least two workers, and for no more than one half hour at a time.

G. Plastics Division, Blow Molding Department, Cutter

1. Provide a mechanical means to remove the large accumulation of flashing at the top and bottom of the molded pails. These are the two steps in the operation that require the most muscular effort.

2. Lower the height of the work table to eliminate shoulder abduction while performing trimming operations. The height of the table should be such that the elbows are at the worker's side with the hands just below the level of the elbow.

3. Ensure that knives are kept sharp and that the handles on the knives are large enough (about 1.5 inches in diameter) to be held comfortably in the hand. The length of the handle should be such that it is supported by the fleshy portions of the hand and not by the soft tissue of the palm.

4. Identify or create light duty work into which cutters can rotate. Time spent trimming pails should be restricted to at most one-half of a work shift.

H. Metal Container Division, Press Room, Stamp Holes in Lids

1. Provide a means for each finished lid to be dispensed with at table height, rather than stacked and moved out of the way by the worker when the stack height becomes excessive. A spring-loaded, recessed receptacle located to the right within easy reach of the worker is one alternative.

2. Locate the gasket rings placed on the holes after the stamping operation in a gravity feed bin between the machine and the table where completed lids are dispensed. The opening of this bin should be at the height of the point of operation of the punch press so that the gasket could be placed on the stamped hole with one smooth movement of right hand just after the lid is removed from the punch press. The recommended orientation of the bin would also eliminate the need for the worker to reach to his/her side to retrieve a gasket ring.

3. Provide an adjustable chair with back support so that the worker can get closer to the operation, if desired, and also remove lids from the press machine without extending the wrist.

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1. International Chemical Workers Union (ICWU), The National Office, Akron, Ohio
2. ICWU Local 862, Peotone, Illinois
3. Growth International, Bennett Industries, Peotone, Illinois
4. OSHA, Region V

For the purpose of informing affected employees, copies of this report should be posted by Bennett Industries in a prominent place that is accessible to employees for a period of 30 calendar days.

TABLE 1

REPORTED CARPAL TUNNEL SYNDROME (CTS) AND
OTHER CUMULATIVE TRAUMA DISORDER (CTD) CASES
(January 1986 to June 1989)

BENNETT INDUSTRIES
PEOTONE, ILLINOIS
HETA 89-146

	Plastics Division		Metals Division		Total
	Shrink ring operator	Cutter	Silkscreener	Drum line operator	
CTSs	10	3	1	---	14
Other CTDs	6	1	---	3	10
Total CTDs	16	4	1	3	24

TABLE 2

QUESTIONNAIRE RESULTS

BENNETT INDUSTRIES
PEOTONE, ILLINOIS
HETA 89-146

	Plastics	Metals	Prevalence* Ratio	95% Confidence Interval
Number of respondents	77	21		
Pain within the past month in:				
Upper extremity	55 (71%)**	11 (52%)	1.4	0.9 - 2.1
Hands	36 (48%)	8 (38%)	1.3	0.7 - 2.3
Forearms/elbows	29 (38%)	5 (24%)	1.6	0.7 - 3.6
Shoulders	28 (36%)	6 (30%)	1.2	0.6 - 2.5
Neck	25 (33%)	6 (30%)	1.1	0.5 - 2.3
Within past month received medical treatment for:				
Carpal tunnel syndrome	9 (14%)	1 (5%)	3.0	0.4 - 22
Ganglionic cyst	3 (5%)	1 (5%)	1.1	0.1 - 10
Tendonitis (wrist)	5 (8%)	0 (0%)	Indeterminate***	------

* (Prevalence of symptoms in plastics division) / (Prevalence of symptoms in metals division)

** Number and (%) of respondents

*** p=0.32, Fisher's exact test, 2-tailed