Ergonomics Best Practices for Manufacturing

Many of the injuries in manufacturing are musculoskeletal disorders caused by cumulative trauma. We call these injuries that result from cumulative wear and tear cumulative trauma disorders (CTDs). Back injuries, tendinitis and carpal tunnel syndrome are examples of common CTDs. Workplace risk factors for CTDs include repetitive motions, high forces, awkward postures and vibration exposure. CTDs in manufacturing can be associated with such activities as manual material handling, hand tool usage, awkward postures and prolonged equipment operation.

The ergonomics process

One effective way to reduce the risk of CTDs such as carpal tunnel syndrome and back injuries is to establish an ergonomics process. Do not regard ergonomics processes as separate from those intended to address other workplace hazards. Use the same approaches to address ergonomic issues—hazard identification, case documentation, assessment of control options and health-care management techniques that you employ to address other safety problems. It is important to realize that you cannot combat-cumulative disorders effectively with a quick-fix program. Rather, a long-term process, which relies on continuous improvement, is the preferred approach to reducing CTDs. Successful programs not only result in reduction of injuries, but they achieve quality and productivity gains, as well.

For an ergonomics process to be successful, it is imperative that management is committed to the process, participates in the process and provides the necessary resources to ensure its success.

Include the following elements as part of effective management commitment:

1. Issue policy statements that;

- Treat ergonomic efforts as furthering the organization's goal of maintaining and preserving a safe and healthy work environment for all employees;
- Expect full cooperation of the total work force in working together toward realizing ergonomic improvements;
- Assign lead roles to designated persons who are known to make thing happen;
- Give ergonomic efforts priority with other cost reduction, productivity and quality assurance activities;
- Have the support of the local union, if applicable;

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2. Hold meetings between employees and supervisors that allow full discussion of the policy and the plans for implementation;

3. Set concrete goals that address specific operations. Goals give priority to the jobs posing the greatest risk;

4. Commit resources to;
- Train the work force to be more aware of ergonomic risk factors for work-related CTDs;
- Provide detailed instruction to those expected to assume lead roles or serve on special groups to handle various tasks;
- Bring in outside experts for consultations on start-up activities and difficult issues until you develop in-house expertise;
- Implement ergonomic improvements as required;
- Provide release time or other compensatory arrangements during the workday for employees expected to handle assigned tasks dealing with ergonomic concerns;
- Furnish information to all those involved in or affected by the ergonomic activities to be undertaken;
- Provide evaluative measures to track the results of the ergonomic process to indicate that progress has been made and if plans need to be revised. Reporting results of the process and publicizing notable accomplishments also emphasize the importance of the process and maintain the interest of those involved.

Employee involvement

Promoting worker involvement in efforts to improve workplace conditions is a critical element to an ergonomics process. It also has several benefits, including:

- Enhanced worker motivation/job satisfaction;
- Added problem-solving capabilities;
- Greater acceptance of change;
- Greater knowledge of the work and organization.

Task force development

Ergonomic issues typically require a response that cuts across a number of organizational units. An ergonomics task force provides an excellent forum to secure input and cooperation from these units. In addition to management and the work force, secure participation from:

- Safety personnel;
- Health-care providers;
- Human resources personnel;
- Maintenance;
- Purchasing;
- Ergonomics specialists.

Clearly define the roles and responsibilities of each team member, including determining who will document problems and monitor project progress.

Training

Training is an essential element for any effective safety and health program. Train all staff members to:

- Recognize workplace risk factors for CTDs and understand general methods for controlling them;
- Identify the signs and symptoms of CTDs that may result from exposure to such risk factors, and be familiar with the organization's health-care procedures;
- Understand the process the employer uses to address and control risk factors, the employee's role in the process, and ways employees can actively participate.

All ergonomic task-force members should receive advanced training in job analysis and control measures, problem identification, and in team building and problem solving.

Best practices from the BWC SafetyGRANT$ program

The preferred approach to the prevention and control of CTDs is to design the job taking into account the capabilities and limitations of the work force. Design jobs so that CTD risk factors such as high forces, awkward postures and repetitive motions are minimized.

The BWC SafetyGRANT$ program has provided assistance to manufacturing facilities to help them reduce the risk of CTDs in the workplace. As part of the program, BWC has collected job designs the industry uses to reduce the risk of CTDs in their workplaces.

Participating companies report the effectiveness of the interventions by measuring CTD incidence rates, lost days due to CTDs, restricted days due to CTDs and employee turnover. They also measure the relative risk of injury by completing risk factor assessments for affected tasks. These assessments provide a measure of the relative risk of injury for a specific task.

BWC calculated a return-on investment (ROI). Assumptions include:

1. $29,000 per incident (www.backsafe.com);
2. Every dollar saved in injury reduction is available purchasing power to the employer;

3. BWC normalized data to calculate the injuries and costs that would occur in an equivalent one-year follow-up period. In this way, direct comparisons could be made between the baseline and follow-up periods;
4. BWC did not consider time value of money in the calculations.

The following are situations frequently encountered in manufacturing facilities that can lead to CTDs and demonstrated solutions (best practices) to alleviate those problems.

Manufacturing ergonomic best practices

Situation – manual materials handling
According to OSHA, "Manual materials handling is the principal source of compensable injuries in the American work force, and four out of five of these injuries will affect the lower back." Manual materials handling often involves the following risk factors, which can increase the likelihood of back injuries. These include:

- Lifting heavy loads;
- Carrying bulky loads or loads far away from the body;
- Frequent lifting;
- Bending the trunk, as when picking items up off the floor or when reaching into a bin;
- Twisting the trunk;
- Static loading, such as holding or carrying objects for long periods of time;
- Pushing or pulling.

Back injuries account for approximately 40 percent of Ohio's workers' compensation costs, and you can attribute many of these cases to manual materials handling. You can use the risk factors for low back pain by incorporating lifting aids, lift assists or transport assists.

Best practice – lifting aid
You can install lifting aids to lift, tilt and/or turn materials. These devices do not eliminate the need to handle material, but they can aid in locating materials so employees can handle them with minimal trunk flexion and minimal reaching. Hence, the forces on the spine are reduced as is the risk of back injury. Powered and spring-loaded lift tables are examples of lifting aids.

Best practice – lift assist devices
Lift assist devices use mechanical means to lift materials; thus, reducing work exposure to the risk factors commonly associated with manual materials handling. These devices greatly reduce the forces on the body by using mechanical means (usually electric, hydraulic or pneumatic) to provide the lifting power. Such devices include hoists, cranes, manipulators and vacuum lifters.

Best practice – transport devices
Manually transporting material often involves lifting, carrying, pushing or pulling. These activities all have the potential to generate large forces in the hands, wrists, elbows and shoulders. These large forces can, in turn, lead to injuries in the affected body part. Transport devices reduce the risk of injury by providing the force through mechanical means or, as in some cases, eliminating the need to manually handle the material at all. Examples of transport devices include carts, conveyors, tugs, powered dollies and forklifts.

Results (lifting aid, lift assist devices, and transport devices)
Sixty-five manufacturing companies that received lift assists, aids and/or transport devices achieved the following results after an average follow-up period of 214 days:

1. The CTD incident rate (incidents per 200,000 hours) changed from 9.8 to 4.9 – a 50-percent improvement;

2. The ROI for lifting aids, assist devices and transport devices is .83 years or 10 months;

3. The days lost due to CTDs improved from 110 days per 200,000 hours worked to 36.2 – a 70-percent improvement;

4. The restricted days due to CTDs decreased from 102 days per 200,000 hours worked to 39.5 – a 61-percent improvement;

5. The turnover rate (per 200,000 hours worked) declined from 53.2 to 44.5 – a 16-percent improvement;

6. The average risk factor score for 120 affected tasks in the 65 companies was 33 before putting the devices into place and 19 afterward – a 42-percent improvement.

Situation – stretch wrapping
Stretch wrapping material on pallets by hand creates awkward postures in the trunk and in the shoulders. Employees ofen hold these awkward postures for extended periods as they apply stretch-wrap around the pallets

Best practice – stretch-wrapping machine
Stretch wrapping machines are commercially available that automatically wrap the material. Generally, a fork truck or pallet jack delivers pallets of material to the machine, and employees then activate the machine. Once the machine wraps material, employees remove the pallet of material.

Results (stretch wrapping machine)
Three manufacturing locations that incorporated stretch-wrapping machines achieved the following results after an average follow-up period of 373 days:

1. The CTD incident rate (incidents per 200,000 hours) changed from 9.2 to 7.9 – a 14-percent improvement;

2. The ROI for stretch-wrapping equipment is two and one-half years;

3. The days lost due to CTDs dropped from 369 days per 200,000 hours worked to 0 – a 100-percent improvement;

4. The restricted days due to CTDs decreased from 125 days per 200,000 hours worked to 39.3 – a 69-percent improvement;

5. The turnover rate (per 200,000 hours worked) declined from 94.6 to 35.3 – a 63-percent improvement.

Situation – hand-tool use
Prolonged or repetitive hand-tool use can lead to increased rates of upper extremity CTDs such as tendinitis or carpal tunnel syndrome. The increased risk stems from the following risk factors:

1. High force requirements;
2. Awkward wrist postures (i.e., bending the wrist);
3. Repetitive motions;
4. Contact stresses, such as when the base of the tool presses against the base of the wrist.

Best practice – powered hand tools with ergonomic design features
Ergonomic hand-tool design can reduce the CTD risk factors. Consider these design guidelines when using hand tools in manufacturing processes.

Power tools
- Use whenever feasible
- Trigger design
- Thumb-activated is preferred over use of other fingers
- If finger activated — use two or more fingers
- Isolate or dampen vibration
- Provide protection from exhaust and from heat generated by motor or tool bit

Force requirements
- Use counterbalance mechanisms for heavy tools (weight > two pounds)
- Spring-loaded to eliminate manual exertion necessary to open handles

Shape, size and orientation

- Avoid ridges or flues
- Length of handle - minimum of 4 inches
- Handle diameter - minimum of 1.5 inches
- Handle span - maximum of 3 inches
- When using bent handles, consider direction of motion and force exertion and take into account the work station layout

Handle Material

- Must provide padding
- Should be non-porous
- Must provide good coefficient of friction
- Should be non-conductive

Grasping force

- Minimize grip forces
- Power grips are preferred over pinch grips
- Use properly-sized tool grips
- Use two-handed grips to distribute force exertions

Posture

- Wrists should be in line with the hand and forearm

Results (hand tools)

Two manufacturing locations that incorporated ergonomically designed powered hand tools achieved the following results after an average follow-up period of 298 days:

1. The restricted days due to CTDs improved from 57.1 days per 200,000 hours worked to 44.8 – a 22-percent improvement;

2. The ROI for hand tools is undeterminable at this time due to lack of data to accurately measure;

3. The turnover rate (per 200,000 hours worked) fell from 28.4 to 17.3 – a 39-percent improvement;

4. The average risk factor score for six affected tasks in the two companies was 23.5 before putting the hand tools into place and 20.7 afterward – a 12-percent improvement.

Situation – work station design

Many manufacturing facilities have workstations where parts are cleaned, assembled or packed. The following risk factors are often present at these workstations:

1. Prolonged standing on a hard surface – this condition can lead to poor blood flow in the legs, feet and back, fatiguing the worker;

2. Just as prolonged standing can lead to problems, prolonged sitting can also create stresses on the back by forcing the back to curve outward. Seats with inadequate padding and adjustability also can place contact stresses on the legs and buttocks, which impedes blood flow;

3. Reaching into small parts bins or boxes often causes the worker to flex the wrist (bend the wrist toward the palm). Frequent wrist flexion is associated with an increased risk of CTDs, such as carpal tunnel syndrome. Reaching also can lead to stresses on the shoulders and back.

Best practice – ergonomic workstation design

Incorporate good ergonomic principles into workstation design. Examples of these principles that the SafetyGRANT$ program incorporates include:

- Anti-fatigue floor mats;
- Chairs with proper ergonomic design features;
- Reduced wrist flexion.

1. Provide anti-fatigue floor mats in areas where employees stand for long periods of time. The matting should have beveled edges to avoid tripping, be of sufficient thickness and size, and be durable.

2. Provide chairs with proper ergonomic design features where workers must sit. These features include:

- Adequate lumbar support;
- Adequate adjustability, especially in height, to fit a wide range of users;
- Controls should be easy to reach and operate;
- Armrests (unless they become an obstacle when reaching or getting close to the workstation);
- Adequate padding to avoid contact stresses on the legs;
- A stable chair or stool; having a 5-foot base helps.

Since prolonged sitting and prolonged standing are both stressful to the body, allow the worker to alternate between sitting and standing whenever possible.

3. Reduce wrist flexion when reaching into boxes by orienting the heights and angles. Furthermore, you can use clips to hold the lids down so that the worker doesn't have to reach around or over them.

Results (ergonomic workstation design)
Nine manufacturing locations that incorporated ergonomic workstation design accomplished the following results after an average follow-up period of 247 days:

1. The CTD incident rate (incidents per 200,000 hours) changed from 10.0 to 1.6 – an 84-percent improvement;

2. The ROI for ergonomic workstation design is .37 years or four months;

3. The days lost due to CTDs decreased from 24.9 days per 200,000 hours worked to 16.0 – a 36-percent improvement;

4. The restricted days due to CTDs dropped from 58.5 days per 200,000 hours worked to 6.4 – a 61-percent improvement;

5. The average risk factor score for 29 affected tasks in the nine locations was 29.7 before putting the design changes into place and 17.5 afterward – a 43-percent improvement.

Situation – manual labor involved in assembly, processing, and materials handling
A variety of situations exist in manufacturing where hands-on, labor intensive activity is required. These activities often involve risk factors for CTDs. One example is when a worker manually removes the welding flash with a sharp hand tool. This repetitive activity creates awkward wrist postures and high forces, particularly on the base of the wrist. Another example is when a worker must apply a large amount of torque to a work piece. This activity generates relatively large forces in the hand, wrist, elbow, and shoulder. These high forces, couple with the awkward postures, increase the likelihood of an upper extremity CTD.

Best practice – automation
When automation is implemented, the process is completed entirely by machine. The worker now usually has the role of operating, monitoring and sometimes loading the machinery. Examples of automation include CNC machines, automatic case packers and palletizers.

Results (automation)
Twenty-four manufacturing locations that incorporated automation achieved the following results after an average follow-up period of 214 days:

1. The CTD incident rate (incidents per 200,000 hours) changed from 10.4 to 7.2 – a 31-percent improvement;

2. The ROI for automation is 5.8 years;

3. The days lost due to CTDs decreased from 123 days per 200,000 hours worked to 23.1 – an 81-percent improvement;

4. The restricted days due to CTDs declined from 239 days per 200,000 hours worked to 57.4 – a 76-percent improvement;

5. The turnover rate (per 200,000 hours worked) fell from 103 to 43.1 – a 58-percent improvement;

6. The average risk factor score for 46 affected tasks in the 24 locations was 28.5 before putting the devices into place and 15.4 afterward – a 46-percent improvement;

Best practice – semi-automation
When semi-automation is implemented, a particularly hazardous part of the job is usually automated. However, the intervention still requires substantial operator involvement such as operating the machine and providing continuous control. Examples of semi-automation include controlled lathes, saws, grinders and presses.

Results (semi-automation)
Sixteen manufacturing locations that incorporated semi-automation accomplished the following results after an average follow-up period of 229 days:

1. The CTD incident rate (incidents per 200,000 hours) changed from 32.4 to 9.7– a 70-percent improvement;

2. The ROI for semi-automation is 1.7 years;

3. The days lost due to CTDs fell from 215 days per 200,000 hours worked to 63.0 – a 71-percent improvement;

4. The restricted days due to CTDs dropped from 197 days per 200,000 hours worked to 0 – a 100-percent improvement;

5. The turnover rate (per 200,000 hours worked) decreased from 94.6 to 64.6 – a 32-percent improvement;

6. The average risk factor score for 17 affected tasks in the 16 locations was 21.4 before imlementing the semi-automation and 10.4 afterward – a 51-percent improvement.

Case studies from SafetyGRANT$

Can employers reduce injuries in their workplaces? The answer is unequivocally yes! Through the SafetyGRANT$ program, BWC has collected data on the effectiveness of installing ergonomic interventions in industrial workplaces. The following case studies demonstrate that by incorporating ergonomic best practices into the design of tasks and by using good safety management processes, you can reduce the risk of injuries, including CTDs. Ergonomic best practices worked for them, and they can work for you, too.

BWC has analyzed data on injuries from manufacturing facilities that have received SafetyGRANT$ to install ergonomic interventions like those mentioned in the best practices described above. These manufacturing facilities have reported their baseline (before ergonomic intervention) and follow-up (after ergonomic intervention) data, with an average follow-up period of 219 days. Here's what we have found:

- The CTD incidence rate decreased from 9.4 CTDs per 200,000 hours to 6.4 CTDs per 200,000 hours worked — a 32-percent improvement;
- Lost days due to CTDs dropped from 87 days per 200,000 hours worked to 42 days per 200,000 hours worked — a 52-percent improvement;
- Restricted days due to CTDs changed from 111 per 200,000 hours worked to 74.7 days per 200,000 hours worked – a 33-percent improvement;
- The turnover rate fell from 82.4 (per 200,000 hours worked) to 26.4 – a 68-percent improvement;
- The average risk factor score (a relative measure of the risk of CTD for 397 tasks in the 208 manufacturing areas declined from 31.7 (before the ergonomic intervention) to 18.5 (after the intervention) — a 42-percent improvement.

The best practices described above are just a few of the ergonomic interventions that employers can be incorporate into industry. For more information about safety in the workplace or for assistance with your operation, please contact BWC's Division of Safety and Hygiene at 1-800-OHIOBWC, and listen to the options, or visit our Web site at ohiobwc.com.

Oxford Automotive, Masury

Situation
Oxford Automotive is a Tier I automotive supplier that produces metal stampings and assemblies of suspension components for light trucks. A packer, at the end of each press line, places the parts into a metal basket. These baskets are then either sent out to have the parts painted or are sent to welding workstations. Prolonged standing at the workstations, repeated bending into metal baskets and working above shoulder height are some of the risk factors involved. These conditions are associated with an increased likelihood of back pain.

Solution
Oxford Automotive purchased 20-tilt stands and 100 grip mats. Height adjustable tilt tables reduce bending and reaching from the waist. Anti-fatigue matting alleviates the static loading associated with continuous standing at workstations all day.

Results – after seven months
- The project cost $22,986 (BWC contributed $18,388.80.).
- The CTD rate went from 95.2 CTDs per 200,000 hours worked to 11.2 CTDs per 200,000 hours worked in the seven-month period after the intervention was put into place – an 88-percent improvement.
- The lost days rate (due to CTDs) declined from 71.4 days lost per 200,000 hours worked to 0 – a 100-percent improvement.
- The restricted days rate (due to CTDs) dropped from 190.4 restricted days per 200,000 hours worked to 44.9 days per 200,000 hours worked – a 76-percent improvement.
- The risk factor assessment scores changed from an average of 52 to 36.5 – a 30-percent reduction.

Liberty Steel Products

Situation
Liberty Steel Products is a welding/fabrication job shop that focuses on shearing, burning and welding of all metals. Risk factors associated include upper body/torso twisting from movement of the sheet into the sheer, pushing and positioning sheet during cutting, and repetitive bending over and lifting of cut pieces from the back of the shear. Other risk factors are repetitive grinding, which has risk factors of vibration and static posture, and use of upper body force and elbows while clamping and unclamping the metal sheets.

Solution
Liberty Steel Products purchased a new shear that keeps employees from being exposed to repetitive bending. A stacker keeps cut metal from falling to the floor. The new shear cuts the metal parts cleaner, which means the previous method of deburring by grinding is not necessary. Also, a ball conveyor will be equipped on the front end of the shear to enable the employee to move the metal plate around more easily when preparing for cutting. The new shear will hold the plate in place, so that the employee does not have to clamp down the plate each time he or she makes a cut.

Results
- The project cost $57,500 (BWC contributed $40,000).
- Risk factor scores went from an average of 36 to 5.
- After one year, the CTD rate, lost-days rate and restricted-days rate remain at 0.
- Before installing the shear, the average time to complete a piece was 16.35 seconds. At six weeks after the intervention, the average time to complete a piece was 10.95 seconds; at six months average time to complete a piece was 8.33 seconds; and at 12 months, the average time to complete a piece was 7.60 seconds.

Screens Technology, Youngstown

Situation
Screens Technology manufactures preassembled roll formed and extruded window/patio screens. Screen frames are cut to length, placed in tote bins and transported to an assembly station. Pressing corner keys into the precut lengths assembles the frames. The assembled frames are transported to hand wiring stations where they are placed on an adjustable and wiring table and blocked with side blocks. The operator pulls the screen cloth over the assembled screen frame from a payoff reel. Spline secures the screen cloth in a channel, then, the operator uses a spline roller to push the spline into the channel. Ergonomic related issues with this operation are:

1. The operator is exposed to awkward postures in the back, shoulders and wrist because he or she must push forward, to the left, downward, then, to the right to wire the screen. The larger screens require a greater stretch, which increases the awkward posture and unnatural forces on the body;

2. Repetitive motion is required when using a wooden handle spline roller (industry standard) to force the spline into the spline channel that holds the screen securely in place;

3. The worker is exposed to high forces — The operator must grip the spline roller tightly while pushing downward, which requires high force and contact stresses on the soft tis-

sues and blood vessels in the hand. These high forces are translated into the elbow, shoulder and back. The force and pressure required to wire the aluminum screens causes immediate discomfort and pain to the hand, wrist, arm and back.

Solution

Screens Technology purchased semi-automated wiring tables, which reduced the awkward postures and high forces that increase likelihood of CTDs. According to Screen Technology, the new tables also improve quality, increase productivity and reduce operator fatigue. The company has stated that the new table also has boosted employee morale.

Results

Screens Technology was awarded $32,000 from the BWC Safety-GRANT$ program; total equipment cost was $40,000.

- Risk factor scores went from 29 before the intervention to 19 after the intervention.
- At 18 months after implementing the tables, the CTD incidence rate dropped from 69 CTDs per 200,000 hours worked (before the intervention) to 0 CTDs afterward.
- At 18 months after implementing the tables, the CTD lost-days rate decreased from 2342 CTDs per 200,000 hours worked (before the intervention) to 0 lost days afterward.
- At 18 months after implementing the tables, the CTD restricted-days rate fell from 275 CTDs per 200,000 hours worked (before the intervention) to 0 restricted days afterward.