NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2006-0239-3040
General Electric Aviation
Engine Services Distribution Center
Erlanger, Kentucky

March 2007

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 J. Habes, SangWoo Tak, and Jessica Gordon of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Consultative assistance was provided by Larry Murphy, Division of Applied Research and Technology (DART). Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

Copies of this report have been sent to employee and management representatives at General Electric and the OSHA Regional Office. The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) at General Electric Aviation (GE) Engine Services Distribution Center in Erlanger, Kentucky. The company submitted the HHE request because they were concerned that some workers may be at risk of strained backs, pulled shoulders, and twisted knees from performing their jobs. NIOSH investigators conducted site visits in May, June, and July 2006.

What NIOSH Did

- We watched and took pictures of workers receiving parts, storing parts, picking parts, and shipping orders to customers.
- We distributed a survey to workers for information about quality of working life.
- We reviewed OSHA 300 injury logs.

What NIOSH Found

- Workers have to bend and reach too much while performing their jobs.
- Some workers lift heavy parts without mechanical assistance or help from other workers.
- Workers say they have aches and pains from their work but usually don't report them.
- Workers at GE are more satisfied with their working conditions than workers at other companies.

What GE Managers Can Do

- Design storage areas so that parts don't have to be located near the floor.
- Design assembly areas with more counter space so workers don't have to bend over to fill orders.
- Provide portable lifting and moving equipment for handling heavy parts.
- Provide more training for workers so they can recognize unsafe work practices and more easily identify the early signs of injury.

What GE Employees Can Do

- Report injuries or unsafe work conditions to management.
- Take the time to work safely and lift properly.
- Actively participate on safety and ergonomics committees.

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2006-0239-3040

Health Hazard Evaluation Report 2006-0239-3040
General Electric Aviation
Engine Services Distribution Center
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March 2007

Daniel J. Habes, MSE, CPE
SangWoo Tak, ScD, MPH
Jessica Gordon, MS

SUMMARY

On May 9, 2006, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from the Voluntary Protection Program coordinator at the General Electric Aviation (GE) Engine Services Distribution Center in Erlanger, Kentucky. The request stated that 88 material handlers who pick and or package jet aircraft engine parts may be at risk of strained backs, pulled shoulders, and twisted knees from performing their jobs. On May 26, 2006, NIOSH investigators held an opening conference with representatives of GE management and United Auto Workers Local 647, followed by a walk-through of the work areas to observe some of the typical receiving, order picking and parts packaging tasks. On June 27, 2006, and July 20, 2006, we delivered medical questionnaires and viewed job tasks not performed during the initial visit. A closing conference was conducted on the latter date.

The ergonomics evaluation indicated that the most common risk factors for the development of musculoskeletal disorders were bending and reaching to pick parts, store parts, and ship parts. There were also some areas where heavy lifting of parts was a risk factor. The Occupational Safety and Health Administration (OSHA) Form 300 Log of Work-Related Injuries and Illnesses review indicated that five workers reported musculoskeletal disorders of the upper extremity, knee, and low back for the years 2003-2005. Results of the questionnaire indicated that 55% of 73 workers who participated were experiencing pain or discomfort in one or more body parts. Overall, workers were satisfied with working conditions, equipment and information provided to them, and supervisory support.

NIOSH investigators conclude that a health hazard exists at the GE Engine Services Distribution Center due to the unassisted lifting of heavy objects in the receiving and assembly areas and bending and reaching to store, retrieve and ship parts at the facility. Recommendations for reducing the risk of injury are contained in this report, including the use of portable lifting equipment and improved workplace design.

Keywords: NAICS 423860 (Transportation Equipment Supplies [except motor vehicle] Merchant Wholesalers), musculoskeletal disorders of the back, knee and upper extremity, ergonomics, bending and reaching, NIOSH quality of worklife survey.

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INTRODUCTION

On May 9, 2006, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the Voluntary Protection Program (VPP) coordinator at the General Electric Aviation (GE) Engine Services Distribution Center in Erlanger, Kentucky. The request stated that 88 material handlers who receive, pick, and or package jet aircraft engine parts may be at risk of strained backs, pulled shoulders, and twisted knees from performing their jobs. On May 26, 2006, NIOSH investigators conducted an opening conference, attended by representatives of GE management and United Auto Workers (UAW) Local 647. During a general walk-through of the work areas, we observed some of the typical receiving, order picking, and parts packaging tasks. On June 27, 2006 and July 20, 2006 we delivered medical questionnaires and viewed job tasks not performed during the initial visit.

BACKGROUND

The GE Engine Service Distribution Center receives and delivers aircraft engine parts from and to GE facilities in Evendale, Ohio; Durham, North Carolina; and its partner in France, Société Nationale d'Étude et de Construction de Moteurs d'Aviation (Snecma). The 400,000 square foot distribution center has been at its Erlanger location since 1985 and employs 130 workers, of whom 88 are material handlers. The distribution center consists of a receiving area, a warehouse, assembly areas, a shipping dock, and an office area.

The company has an employee involvement team that maintains Occupational Safety and Health Administration (OSHA) Injury and Illness 300 Logs, tracks injury near misses, and trains employees regarding ergonomic awareness and back safety. The company also has compiled Safety Risk Assessments (similar to Job Safety Analyses [JSAs]) for each job. These are authored by a member of the employee involvement team and reviewed by the Environmental Health and Safety (EHS) team leader. Few injuries, including musculoskeletal disorders, have been reported over the years. Yet, there remains the perception by union and management that due to the types of tasks performed and the increasing age of the workforce, there is an elevated risk of injury at this facility.

Job Descriptions

Every worker in the distribution center has the general job title of material handler, but job duties and responsibilities among workers vary. Material handlers in the receiving area use fork lift trucks to transport incoming parts and place them onto shelf locations in the warehouse. Other material handlers pick and deliver parts to workers in assembly areas where they are repackaged for distribution, and others pick parts and take them to their own work areas where they pack the parts for subsequent distribution from the center. Parts are picked according to dispatch instructions which are logged onto a hand-held scanner in the possession of each material handler who picks parts. Each fork lift truck is equipped with an in-house-designed attachment called a picker box that serves as a work station and a unit for storing parts picked in the warehouse area. This picker box can also be used as a detachable work station/desk in the assembly or kitting areas where orders are packaged in custom containers called kits. Other job tasks performed by material handlers include assembling pre-cut boxes, cutting boxes for custom orders, sealing boxes with tape, and sealing large boxes with a banding machine. Material handlers in each packing area complete their own routing paper work.

METHODS

Ergonomics

The ergonomics evaluation consisted of a walk-through assessment of the warehouse and order assembly areas to observe workers who stack received parts into storage locations, pick orders,

deliver parts to assembly areas, and complete the repackaging of parts for delivery to external customers. Some work stations were photographed to document the variety of tasks observed.

Epidemiologic

The objectives of the epidemiologic evaluation were to assess the prevalence of musculoskeletal symptoms among employees at the GE Engine Services Distribution Center and to examine the safety perception and psychosocial aspects of the work in the package handling process. To this end, NIOSH provided a self-administered questionnaire to GE supervisors for distribution to the 130 GE Engine Services Distribution Center employees at work during the time of the initial visit. Additional questionnaires were delivered to the facility on June 27, 2006, and July 20, 2006. The NIOSH epidemiologist also picked up completed questionnaires that workers returned to their supervisor on these dates. Questions on the survey asked about work activities and location, present musculoskeletal symptoms, and a series of psychosocial factors, such as job demand and perceptions of safety culture. Perception of safety culture, job resources, and supervisor support were measured using questions from the NIOSH Quality of Work Life (QWL) survey. The QWL survey was part of the General Social Survey that is a biannual, nationally representative personal interview survey of United States households conducted by the National Opinion Research Center, a national organization for research based at the University of Chicago. This questionnaire deals with a wide assortment of work organization issues, such as hours of work, workload, worker autonomy, layoffs and job security, job satisfaction/stress, and worker well-being. The personal interview data were collected in the Fall/Winter of 2002 and the final dataset contains responses from 2,765 persons.[1]

Individual questions were rated on a four-point scale, where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Responses to individual questions were summarized to create a scale. We calculated coefficient alpha for each scale to describe how well the items in each scale were related to each other. Generally, scales with an alpha coefficient greater than 0.7 are considered to be reliable.

The scale for safety climate included four items. Respondents were asked whether they agreed or disagreed with each of the following statements: "safety of workers is a high priority with management at this company," "no significant compromises or shortcuts are taken when worker safety is at stake," "employees and management work together to ensure the safest possible working conditions," and "safety and health conditions of this company are good." The scale ranged from 4 to 16. The alpha was 0.89.

The resource scale included five items. Respondents were asked whether they agreed or disagreed with each of the following items: "receive enough help and equipment to get the job done," "have enough information to get the job done," "free from conflicting demands," "can rely on the people I work with," and "enough time to get the job done." The scale ranged from 5 to 20. The alpha was 0.72.

The supervisor support scale included two items. Respondents were asked whether they agreed or disagreed with each of the following statements: "my supervisor is concerned about the welfare of those under him or her," and "my supervisor is helpful to me in getting the job done." The scale ranged from 2 to 8. The alpha was 0.72.

The prevalence of reported musculoskeletal symptoms occurring in the 6 months prior to the survey was compared between the material handlers and office workers including material handlers' supervisors. In the questionnaire, those who had pain or discomfort in the last 6 months were asked to indicate the extent to which it interferes with their work ("no interference," "some interference," or "had to take to time off work").

Chi-square tests were used to test the significance of the difference in the prevalence of symptoms between material handlers and officer workers. A *P* value less than or equal to

0.05 is considered statistically significant. A *t*-test was used to test the difference in the scales between material handlers and other occupational groups from the QWL national survey.

EVALUATION CRITERIA

Ergonomics

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.[2,3,4,5] The risk of injury appears to increase as the intensity and duration of exposures to these factors increases and the recovery time is reduced.[6] 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.[7]

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.

RESULTS

Ergonomics

The warehouse and assembly areas were well lit and fairly quiet. The most common risk factors we observed for the development of WMSDs were bending over and reaching to pick parts from bins, and bending over and reaching to build a pallet of boxed parts to be shipped out of the GE Engine Services Distribution Center. These work postures occurred mainly in the small parts area and the assembly areas. The small parts area consisted of a four-level rack containing plastic bins into which material handlers placed parts picked from the warehouse so that other material handlers in this area could build custom orders for shipping. We observed that not all of these bins were filled with parts, and there were bins on the lowest and highest shelf tiers that contained parts, while bins on the middle two shelf tiers were not filled.

In the assembly areas, bent back postures were often necessitated by the lack of counter space where employees built orders in custom containers. This lack of adequate work space caused material handlers to place some of the containers on the floor to fill them with parts, or they built pallets directly on the floor. We observed that by elevating the shipping pallet off the floor with other pallets, or varying the height of the pallet with the forks of the lift as it was loaded, bent back postures could be avoided.

While many parts orders were placed into custom containers (kits or shadow boxes), some were placed into standard plastic packing containers with hinged drop-down sides. Not all material handlers took advantage of the drop-down feature, which reduced reaching over the side of the container. We observed handlers at times placing empty shadow boxes on the edge of the bulk bin, due to lack of counter space in the work area. We observed kits with as many as 11 containers. When filled, these containers would then be placed manually into the bulk container. Many orders were shipped in corrugated cardboard boxes assembled by the workers. Workers typically assembled a top, a bottom, and a four-wall section, forming a box that was either taped or banded. One particular box size (48 inches by 44 inches), only used for certain orders, had a three-wall section and a single-wall section. This feature enabled the worker to fill most of the box with only three sides assembled and avoid reaching over the side before closing it up with the fourth side. Some

workers liked and used this feature, but others said it was not worth the risk of having the box contents tumble over during packing. These workers would assemble all four sides of the box and then reach over the side of the box to fill it up with smaller boxes or custom containers specified by the order. All other corrugated box sizes used by the GE Engine Services Distribution Center workers had four-wall sections. Because incoming corrugated boxes are not reused, workers who unloaded smaller containers from a larger one could cut one side to facilitate reaching into the box while unloading. However, some workers cut boxes while others did not.

While most of the work observed was low frequency handling of fairly small parts, some heavy parts were handled in the assembly areas, for example a 78 lb. part from Snecma. This part was unloaded from a box containing many other parts and carried to a storage location in the work area. Although there was a cart in the area, a worker told us that it was easier to just carry the part to the storage location instead of lifting it out of the box, placing it on the cart, and then lifting it from the cart to the storage location. This part arrives about 12 times per week.

We observed heavy-duty vacuum lifts in both the receiving and assembly areas of the distribution center, but these were installed near the far wall of each area, not convenient to use for most pallet transfers. These vacuum lifts were obtained from another GE plant and installed when the GE Engine Services Distribution Center was built. Several workers did not know how to use them or why they were ever installed.

The GE Engine Services Distribution Center used man-up style Crown™ fork lift trucks which enabled the material handlers to pick parts from many locations in the warehouse. All lift trucks were equipped with fully retractable lanyard safety harnesses for high location parts picking. One observed ergonomic problem was a long reach to retrieve parts not located at the edge of pallets. Hooks and a grasping tool with a pistol grip are available to the order pickers for use in these situations.

At the time of the July 20, 2006, visit storage racks for the new GE90 assembly area were being configured, but were not yet finalized. This area was being designed so that parts could be picked from three levels of shelves using a rolling picker (essentially a cabinet with wheels) instead of a forklift truck. The first, second, and third tiers of the shelves were 18 inches high, 42 inches high, and 64 inches high, respectively.

OSHA Log Review

We reviewed OSHA 300 Log summaries for the years 2003-2005. Over that period, 14 incidents were recorded, accounting for a total of 276 lost work days. One lower extremity acute injury that occurred in 2003 accounted for 180 of these days and another acute lower extremity injury in the same year resulted in 39 days of lost work. Of the 14 recordable incidents, five were described as strains or sprains of the shoulder, low back, and knee. One of these five musculoskeletal disorders resulted in 50 lost work days, while the other four resulted in no lost time.

Epidemiologic

Musculoskeletal Symptoms and Job Characteristics

Seventy-three of 130 full-time employees (56%) participated in the questionnaire survey. Forty-nine were material handlers (60% of 81 material handlers), and the rest worked in administrative offices or supervising (five cooperative education [co-op] students were included in the office group). The demographics for survey participants are summarized in Table 1.

Forty employees (55% of the 73 surveyed) reported current symptoms of pain or discomfort in the neck, upper back, low back, knee, shoulder, elbow, forearm, and hand/wrist. These reports included: 11% for the hand/wrist, 33% for the low back, and 25% for the shoulder region. Each person could report symptoms in more than one body area.

There was a difference in the distribution of symptoms between the workers who handled packages and those who worked in the office area. Material handlers reported a higher prevalence of pain in the low back (19 persons, 39%), shoulder (15 persons, 31%), and knee (13 persons, 27%) than the office workers and supervisors. However, differences in the prevalences of symptoms were not statistically significant due to the small number of samples. The only significant difference found was when symptoms were grouped into the category 'any pain' (Table 1).

Thirty-seven percent of all workers participating in the survey (27 persons) reported that pain or discomfort interfered with their work (three persons reported that they had to take time off work due to pain). Material handlers reported work interference due to pain approximately four times more than office workers (49% versus 13%) ($P < 0.05$, degrees of freedom [df] = 1).

Forty-nine percent (35 persons) reported experiencing repetitive or forceful hand movements regularly, 69% (50 persons) reported heavy lifting, and 52% (37 persons) agreed or strongly agreed that their job required fast paced work.

While 96% (47 persons) of material handlers reported heavy lifting as part of their tasks, 13% (3 persons) of office workers reported having to perform heavy lifting tasks. Material handlers also reported a higher percentage (66%, 31 persons) of repetitive hand movements than office workers (17%, 4 persons). The differences between material handlers and office workers in percentage of heavy lifting and repetitive movements were statistically significant ($P < 0.05$, df = 1).

Perception of Safety Climate, Job Resource and Supervisor Support

The average scores and standard deviation for the safety climate, job resource and supervisor support compared to the results from the NIOSH QWL survey are shown in Table 2. On average, participants reported that they agree or strongly agree that the safety management and working conditions of this company are good (mean score = 12). Material handlers agreed or strongly agreed that they are provided the equipment, information, and help they need to perform their jobs (mean resource score = 14). Lastly, material handlers reported that their supervisors were helpful and concerned about the welfare of employees (average support score = 6). The mean scores of material handlers and office workers for safety climate, job resource, and supervisor support were nearly twice that of the national averages ($P< 0.05$).

DISCUSSION

Ergonomics

Based on conversations with the ergonomics team members, the union steward, and the workers, the GE Engine Services Distribution Center employees are dedicated to their work and have a "just get the job done" attitude. This outlook is in part due to many having been at their jobs since the facility opened in 1985 and many having been laid off from the GE manufacturing plant in Evendale, Ohio before joining the distribution center. Despite this positive attitude, there seemed to be a concern among the workers that the injury rate may increase due to their tenure on the job and their advancing age (average = 51 years, including 60% older than 40 years of age).

The "get the job done" attitude appears to have had an effect on the musculoskeletal injury record at the distribution center. More workers reported pain and discomfort on the survey than were reported on the OSHA 300 Logs. It seems that workers were more willing to work through their ailments and accept the risk of injury from lifting heavy objects or from reaching and bending over to retrieve and pack parts than to report musculoskeletal problems as they occurred.

It appears that the company and the employee involvement team have begun to address the

issue of excessive bending because during the two times we returned to the distribution center to deliver questionnaires or view areas that were not in operation during a previous visit, measures had been taken to raise items off the floor. In one assembly area, boxes that were previously on the floor were elevated by three pallets banded together to raise them to a reasonable working height. In the small parts area, a weighing scale was elevated with four unused plastic container bins placed under it. We were also shown newly acquired Creform™ adjustable racks intended for use in the GE90 assembly area that would allow kits to be assembled at comfortable heights chosen by the workers. These racks could also be configured so that picked parts could be placed in tilted shelves to allow for smooth delivery of parts to the workers.

Storage in the small parts area could be further improved by filling the middle two rows of bins before parts are placed in bins on the first or fourth level. When parts are picked in the warehouse by the forklift material handlers, their storage location is determined by the dispatcher. However, this location can be changed by the order picker at the time of delivery. This option could be used to ensure that the middle two rows are filled with parts before storage in the upper and lower tiers takes place.

Some of the work stations most in need of additional storage and lift assist are in the assembly areas handling large parts. Plans are in place to add storage cabinets and table top work space in some areas, but some parts come in such large boxes that they have to be staged in an open area and broken down for storage in the assembly areas. This adds to the distance that large boxes must be transported and suggests the need for portable material handling equipment.

Even with more storage and table top space being added to some assembly areas, it is difficult to have enough room to fill 10 or 11 containers simultaneously. Filling this many containers at once also increases the amount of walking and bending that takes place in the assembly areas. It would be better if parts could be picked in a sequenced manner or sorted in the assembly areas so that three or four kit boxes that are located at a convenient height could be filled and placed on a pallet or in a corrugated box before any more boxes are set out to be filled with parts. However, this arrangement may require dispatching order picks and placing parts in the picker boxes in a fashion that could not be consistently achieved.

In the new GE90 area, the lowest height of the 3-tiered rack (18 inches) was too low for tall workers, and the highest height (64 inches) was too high for small- or average-sized workers. It should be noted that because parts are picked from storage boxes that are grasped at the top and slid from the rack, the height of these boxes should be added to the shelf height to obtain the actual heights to which workers reach when picking parts. Ideally, shelving should be designed so that workers lift primarily between waist and shoulder height to avoid excessive bending and above-shoulder reaching. The Revised NIOSH Lifting Equation guidelines specify that the ideal height at which to initiate a lift is 30 inches.[8]

For maximum safety during order picking, shelf heights should be between the ideal of 30 inches and shoulder height. If this range is not possible, the maximum height to which workers lift (shelf height plus container height) should never exceed eye height for reasons of precision during order picking. Shoulder height and eye height vary between men and women and among different population percentiles (5^{th}, 50^{th}, 95^{th}). The Eastman Kodak series of ergonomics reference books provides anthropometric data for a 50-50 population mix of males and females. According to these data, the 5^{th}, 50^{th}, and 95^{th} percentile shoulder heights for this population are 49 inches, 54 inches, and 60 inches, respectively.[9] Depending on the actual attributes of the population who will be picking orders in the GE90 area, the height to which workers reach for boxes on the shelves should be between 30 and 60 inches to avoid awkward body postures. In order to properly see what is being picked, the height of boxes on the top shelf should not exceed the 95^{th} percentile of the

50-50 male/female population mix eye height, which according to the Eastman Kodak data is approximately 68 inches.

Epidemiologic

Our evaluation found a significant difference between material handlers and office workers in reported musculoskeletal symptoms. Employees perceived a more favorable safety climate, better job resources, and more positive supervisor support compared to the national averages among several occupational groups. The measure of the safety climate scale from the NIOSH QWL is based on individuals' perceptions of the health and safety practices in place where they work. Workers evaluate specific features of their work environment in terms of their personal values and the significance of these features as it affects their overall well-being. Researchers have defined the safety climate in terms of the workers' interpretations of features, events, and processes in the work environment that are perceived to be relevant to their safety.[10] Generally, the safety climate is considered to be related to the general safety level in industrial organizations.[11,12] For example, measures of safety climate correlate with the accident rate, with a better safety climate associated with a lower accident rate.[13] Management commitment to safety and safety training is a significant factor for a safety climate that results in the prevention of occupational injury.[14] Positive perceptions of safety climate at GE may have resulted from a number of initiatives at this company including the management's commitment to safety of its employees.

Traditionally, occupational health and safety has been managed using a control-oriented approach in which managers use their authority to control employee behavior. However, studies have shown that a work force can be better managed by high-involvement oriented strategies. Work systems that involve employees in its performance have a positive impact on occupational safety, and the intensity of the impact is influenced by trust in management and perceived safety climate.[15,16] Even though the employees at the GE Engine Services Distribution Center are involved in the health and safety committee, this team may not be providing the appropriate safety awareness, which may explain why we saw instances of workers not working as safely as they could be (e.g., lifting heavy objects and not adjusting pallet heights).

It should be noted that perceptions of safety climate are distinguished from individual knowledge or behaviors that influence safety in the workplace.[17] Positive perceptions among the employees do not necessarily mean that they are fully knowledgeable and appreciative of the health and safety hazards in the workplace. This is particularly the case given that only 56% of employees participated in our survey. Thus, the results may have been different from the present findings if all employees at this facility had participated. Nonetheless, because we identified some ergonomic hazards at the facility, preventive actions to address these ergonomic hazards should still be a high priority despite the high level of employee satisfaction.

CONCLUSIONS

1. The main ergonomic design problems that place workers at risk of musculoskeletal disorders at the GE Engine Services Distribution Center are low work heights, lack of storage space for parts, lack of counter space for filling kits and other custom containers with parts, and lifting heavy boxes.
2. Material handlers at the GE Engine Services Distribution Center experience many musculoskeletal symptoms that may be related to the physical activities of their jobs, such as prolonged standing, lifting heavy materials, bending and reaching, and repetitive hand/wrist movements.
3. Workers sometimes do not take the time or make the effort to work as safely as they can.
4. The employee involvement team was not providing safety awareness to minimize ergonomic hazards such as

lifting heavy objects and using inappropriate work table heights.

5. Many musculoskeletal injury risk factors were noted during this HHE, but based on improvements observed by the NIOSH team during the two follow-up visits, the company has become more aware of ergonomics problems and the means to correct them.
6. Workers at the GE Engine Services Distribution Center are content with working conditions at their workplace and feel that they are given the resources and supervisory support to effectively perform their jobs.

RECOMMENDATIONS

Based on observations and information collected during this HHE, the following recommendations are offered as a means to prevent the occurrence of musculoskeletal disorders at the GE Engine Services Distribution Center:

1. Encourage each material handler who picks parts from the warehouse to use the hook and gripper tool to pull objects close to the edge of the pallet before lifting. Order pickers should also try to move boxes to the edge of the pallet before departing from a pick location.
2. Assemble kits and pallets for shipment at a comfortable work height, and vary this height as pallets are built. This can be accomplished by raising pallets with unused pallets, using the forklift to raise and lower pallets as they are built or unloaded, and by installing load leveling platforms in areas where other means are not possible or practical.
3. Avoid reaching over the sides of boxes when loading pallets by using the drop-down feature on the plastic containers, cutting the side of a corrugated box as it is being unloaded, or waiting until a box is filled before adding the fourth side (48 by 44 inch box only). Also investigate if other box sizes can be obtained with an open fourth side to benefit those workers who load and unload corrugated boxes.
4. Add more storage and countertop space in assembly areas so kits, shadow boxes, and other containers can be raised off the floor. This is particularly important for orders with multiple containers that are often filled simultaneously. As noted in the Discussion section, sequencing the order in which parts are picked or by arranging parts in the work area so that only a few containers are filled at a time would enable limited tabletop space to be most efficiently utilized.
5. Increase the availability of portable, easy-to-use lift and transport equipment so that workers unloading, storing, and loading heavy boxes, particularly those weighing 50 pounds or more, do not perform such lifts unassisted. Possibilities include portable vacuum lifts, hoists, and portable lift trucks.
6. Ensure that containers are placed at levels that correspond to mid-body heights for most workers to avoid bending and reaching above eye height. An example would be in the GE90 warehouse areas where parts are picked from the floor. The ideal range of effective lifting heights is between 30 and 60 inches, and should not exceed 68 inches. These heights can be achieved in other areas such as the small parts assembly area by storing parts in all locations in the middle two rows before locating parts in the upper and lower shelf tiers.
7. Evaluate the employee involvement team to insure that ergonomic issues in the distribution center are adequately addressed. Encourage active involvement of workers in the design and implementation of work processes to prevent musculoskeletal disorders by more extensive employee participation in ergonomics-related and general safety teams.
8. Provide more training to employees in safe work practices to prevent low back

and upper extremity musculoskeletal disorders and in recognizing the early symptoms of these disorders.

9. Train employees regarding the importance of reporting musculoskeletal disorders as they occur and ensure that there are no disincentives to reporting.

REFERENCES

1. NIOSH [2002]. Quality of worklife questionnaire. http://www.cdc.gov/niosh/qwlquest.html. Date accessed: September 17, 2006.

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

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

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

5. 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. Cincinnati, OH: 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 (NIOSH) Publication No. 97-141.

6. Moore JS, 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.

7. Armstrong TJ, Buckle P, Fine LJ, Hagberg M, Jonsson B, Kilbom A, Kuorinka IAA, Silverstein BA, Sjogaard G, Viikari-Juntura E [1993]. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scand J Work Environ Health 19:73-84.

8. Waters TR, Putz–Anderson V, Garg A [1994]. Applications manual for the revised NIOSH lifting equation. Cincinnati, OH: 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 (NIOSH) Publication 94–110.

9. Eastman Kodak Co, Rodgers SH, ed. [1986]. Ergonomic design for people at work, Volume 2, Van Nostrand Reinhold, New York, NY.

10. Lindell MK [1994]. Motivational and organizational factors affecting implementation of worker safety training. Occup Med 9(2):211-240.

11. Varonen U, Mattila M [2000]. The safety climate and its relationship to safety practices, safety of the work environment and occupational accidents in eight wood-processing companies. Accid Anal Prev 32(6):761-769.

12. Zohar D [1980]. Safety climate in industrial organizations: theoretical and applied implications. J Appl Psychol 65(1):96-102.

13. Huang YH, Ho M, Smith GS, Chen PY [2006]. Safety climate and self-reported injury: assessing the mediating role of employee safety control. Accid Anal Prev 38(3):425-433.

14. Zohar D [2000]. A group-level model of safety climate: testing the effect of group climate on microaccidents in manufacturing jobs. J Appl Psychol 85(4):587-596.

15. Rasmussen K, Glasscock DJ, Hansen ON, Carstensen O, Jepsen JF, Nielsen KJ [2006]. Worker participation in change processes in a Danish industrial setting. Am J Ind Med Sep 49(9):767-779.

16. Zacharatos A, Barling J, Iverson RD [2005]. High-performance work systems and occupational safety, J Appl Psychol 90(1):77-93.

17. Griffin MA, Neal A [2000]. Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation. J Occup Health Psychol 5(3):347-358.

TABLES

Table 1
Frequencies of musculoskeletal pain or discomfort and participants' personal and job characteristics.

	Total (n=73)		Material Handler (n=49)		Office worker (n=24)		*P* value[a]
	Number	%	Number	%	Number	%	
Age (average ± std)	42.4 ± 13.0		47.2 ± 8.8		32.7 ± 14.7		
Job tenure (average ± std)	4.7 ± 6.1		5.8 ± 6.4		2.4 ± 5.0		
Male	53	73.6	40	83.3	13	54.2	< 0.01
Female	19	26.4	8	16.7	11	45.8	
Individual symptoms							
Low back	24	32.9	19	38.8	5	20.8	0.13
Shoulder	18	24.7	15	30.6	3	12.5	0.09
Neck	16	21.9	10	20.4	6	25.0	0.65
Knee	14	19.2	13	26.5	1	4.2	N/A[b]
Forearm	11	15.1	9	18.4	2	8.3	N/A[b]
Hand/Wrist	8	11.0	7	14.3	1	4.2	N/A[b]
Upper back	7	9.6	6	12.2	1	4.2	N/A[b]
Elbow	6	8.2	6	12.2	0	0.0	N/A[b]
Grouped symptoms							
Arm and shoulder[c]	25	34.2	20	40.8	5	20.8	0.09
Neck and back[d]	30	41.1	22	44.9	8	33.3	0.35
Any pains	40	54.8	31	63.3	9	37.5	< 0.05
My work was interfered	27	37.0	24	49.0	3	12.5	<0.01
My job characteristics require the following:							
Heavy lifting	50	68.5	47	95.9	3	12.5	< 0.01
Very fast work[e]	37	52.1	20	41.7	17	73.9	< 0.01
Repetitive hand movements[e]	35	49.3	31	66	4	16.7	< 0.01

[a] Chi-square test was done for the difference between material handlers and officer workers/supervisors.
[b] Chi-square test was not valid due to the small number of symptoms among officer workers.
[c] Include neck, low back and upper back.
[d] Include pains in hand/wrist, elbow, forearm, or shoulder.
[e] Denominator is 71 due to two missing answers.

Table 2
Perception of safety climate, resource and supervisor support among GE distribution employees compared to the national occupational groups.

	Safety Climate		Resource		Supervisor support	
	Mean	Std	Mean	Std	Mean	Std
Office workers (GE) (n=24)	13.52	1.83	15.04	1.55	7.5	0.72
Material handlers (n=49)	11.75	2.60	13.78	4.03	6.38	1.44
National working population (n= 1,643)	6.83	2.47	8.65	2.98	3.49	1.65
Managerial and Administrative (n=269)	6.22	2.12	8.70	2.95	3.36	1.67
Office workers (n=204)	6.67	2.27	8.37	2.96	3.44	1.55
Service (n=249)	7.08	2.72	8.22	3.10	3.68	1.89
Operator, fabricators, and laborers (n=193)	7.13	2.57	5.13	2.91	3.64	1.61

* Note: all the comparisons between material handlers and national occupational groups were statistically significant with *t*-test ($P < .0001$).
Std = standard deviation

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