NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2004-0116-2977
ZF Industries
Tuscaloosa, Alabama

August 2005

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; industries; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Daniel Habes and Richard Driscoll of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

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Highlights of the NIOSH Health Hazard Evaluation (HHE)

Evaluation of Front and Rear Vehicle Axles

In February 2004, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from employees at ZF Industries, Tuscaloosa, Alabama. Workers were concerned that the number of musculoskeletal disorders of the hand and wrist was increasing since the company organized work stations into cells and began "just in time" production methods. The requesters were also concerned that the installation of a new assembly line to produce axles could result in more injuries.

What NIOSH Did

- We watched and videotaped jobs on the front and rear axle lines.
- We talked to workers about their jobs and looked at injury reports.
- We spoke to the consultant who designs the jobs and identifies hazards.

What NIOSH Found

- Assembly parts are not always delivered near the workers, so they have to go get them and carry them to their cell.
- Not all of the jobs have been checked by the company's consultant to see if they are safe.
- Workers have trouble getting correct information about when their workstations will be complete.
- Workers are concerned about fork lift traffic in the plant.
- Some workers have injuries but think they occurred on the old line.
- Workers think that continued overtime will eventually hurt them.
- The method used by the consultant to evaluate jobs is correct.

What Managers Can Do

- Complete work station installation and planned job changes as soon as possible.
- Meet with workers more often to tell them the status of matters that are important to them.
- Complete the Body Part Stress analyses for all jobs so that workers can be sure their jobs are safe.

What the Employees Can Do

- Continue to tell managers what issues bother them.
- Work safely and report any job tasks that may result in an injury.

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 #2004-0116-2977

Health Hazard Evaluation Report 2004-0116-2977
ZF Industries
Tuscaloosa, Alabama
August 2005

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SUMMARY

In February 2004, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation (HHE) from employees at ZF Industries in Tuscaloosa, Alabama. Workers were concerned that the number of musculoskeletal disorders of the hand and wrist was increasing since the company had organized the work stations into cells and implemented lean manufacturing production methods. The requesters were also concerned that the installation of a new assembly line to produce axles at the plant could result in more injuries to the workers. The ergonomics evaluation consisted of observing and videotaping jobs in the front and rear axle departments and a discussion with the company's ergonomics consultant regarding the mechanism used to design jobs and identify musculoskeletal system stressors. The medical evaluation consisted of a review of company safety incident report (OSHA 300) logs for years 2002 through 2004 and confidential interviews with 11 employees chosen at random from a list of workers provided by the company.

The main ergonomic stressors we observed were bending over to lift parts from the floor, from containers and bins, and while unloading pallets due to incomplete implementation of parts delivery systems to the new assembly work stations. Review of injury logs indicated that muscle strain was the most common injury type, and the hand/arm was the most likely injury location. Confidential interviews revealed that workers who were injured thought their injuries occurred on the old assembly line. Workers were concerned about forklift traffic in the plant, having to lift and carry parts to their work stations, incomplete job stress evaluations, and lack of communication regarding the status of planned job changes.

Due to the low production rate, NIOSH investigators conclude that a health hazard does not currently exist at this facility. However, unless planned changes in parts delivery systems and evaluation of the physical stressors of newly designed jobs are completed in a timely manner, worker injuries are likely to occur, particularly as production rises to projected levels.

Keywords: NAICS 336330 (Motor Vehicle Steering and Suspension Components Manufacturing), ergonomics, lifting and carrying tasks, repetitive motions, awkward postures, assembly operations

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INTRODUCTION

In February 2004, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation (HHE) from employees at ZF Industries in Tuscaloosa, Alabama. Workers were concerned that the number of musculoskeletal disorders of the hand and wrist was increasing since the company had organized the work stations into cells and implemented lean manufacturing production methods. The requesters were also concerned that the installation of a new axle assembly line at the plant could result in more injuries to the workers.

During April 26-27, 2005, we conducted a site visit at ZF Industries. Our evaluation team included an ergonomics specialist and an epidemiologist. Following an opening conference, we conducted a plant walk-through inspection, interviewed 11 workers, and observed work tasks on the front and rear axle lines. A closing conference was held on April 27, 2005.

BACKGROUND

Facility Description

ZF Industries, a subsidiary of ZF Friedrichshafen AG (Germany), has been producing front and rear axle systems for the Mercedes M-Class vehicles since 1996. Approximately 230 production workers assemble the axles, which are delivered to the Mercedes-Benz U.S. International plant located in nearby Vance, Alabama. The company plans to increase the number of workers from 230 to 260 to accommodate planned increases in production. Workers at ZF Industries are represented by United Auto Workers (UAW) local 2083.

At the time of the HHE request (February 2004), ZF Industries was assembling an axle (163) that was scheduled to be replaced in December 2004 by a heavy duty and more advanced 164 axle. The plan was to continue assembling the 163 axle while the new line for the 164 axle was being configured in another part of the plant. Prior to and during the transition to the new axle, the company was in the process of adopting a "just in time" production method and a "cell" work station arrangement. Just in time means the company assembles only the number of axles ordered by the Mercedes-Benz plant per day, and the arrangement of jobs into cells fixes the job rotation pattern for workers to only those jobs in their assigned cell.

We originally scheduled the site visit for December 2004 when the new axle line was to be operational. The line was not running to capacity in December 2004, so we rescheduled our visit for the spring of 2005. At the time of this evaluation ZF Industries was still only assembling about two-thirds of projected output. (Mercedes-Benz considers the number of M-Class vehicles produced per day as classified information, so throughout this report production numbers will be referred to as a percentage of projected full output.)

Job Description

Workers at ZF Industries assemble parts brought into the plant from outside suppliers, sending completed axle assemblies to the Mercedes-Benz plant for final assembly. There are no production operations in the plant such as metal stamping or fabrication, cutting raw stock, or welding. As such, the plant is clean and appears free of environmental contaminants such as the dust or smoke often seen in other production facilities. The environment is also well-lit and fairly quiet.

Each of the two lines (front and rear axle) begins with the introduction of a chassis to a moving conveyor line. From that point on, workers add parts such as differentials, constant velocity (CV) joints, control arms, sway bars, and brake components. Most of the parts are added to the line through the use of suspended mechanical assists that not only lift the parts out of bins and pallets, but also position the parts properly on the axle assembly. The company policy is to provide suspended lift assists for any parts

weighing 25 pounds or more. Many of the rotational positions also have specialized tools or mechanical devices such as torque wrenches that secure the parts into place. Workers rotate to other positions in their cell about every two hours.

Ergonomics Program

The main components of the program to control the incidence of work-related musculoskeletal disorders (WMSDs) at ZF Industries are job rotation in the cells and a method used to calculate a Body Part Stress Index (BPSI) to identify potentially hazardous jobs or job tasks. The BPSI, computed by Auburn Engineers, the company's consultant, is a system of assigning job stress levels of 0 (no activity or exertion) to 6 (high level of activity or exertion) to 10 separate body parts (hand/wrist, elbow, shoulder, foot, ankle, knee, hip, neck, and upper and lower back). The criteria applied to each job are based on acceptable muscle force, repetition, and posture levels described in the ergonomics literature. The algorithm for assigning an overall risk level to a job is proprietary to Auburn Engineers, but the goal is to eliminate all jobs or job tasks that rate a 6 on the BPSI, and to ensure that the sum of BPSIs in a worker's rotation is less than or equal to a predetermined number. Lack of a clear understanding of "just in time" theories, cell arrangement of jobs, and the manner in which BPSIs are assigned to jobs were the main triggers for the request of this HHE. The requesters wanted an unbiased assessment of the methods the company uses to design jobs and assign workers, particularly since most of the jobs are new due to the switch to a new Mercedes-Benz axle.

Medical management, consisting of light duty job assignment for injured workers and work restrictions based on worker capabilities during rehabilitation, is another component of the company's program to control losses from worker injuries.

A team of workers meet regularly to evaluate jobs and suggest changes to the company. The group, called the "lean team," has had periodic ergonomics training to support its efforts.

METHODS

Ergonomics

The ergonomics evaluation consisted of a walk-through of the plant to view the variety of job tasks workers perform to produce the front and rear axles. We also held discussions with the consultant from Auburn Engineers to understand how job tasks are arranged and how risk of musculoskeletal disorders is rated for each job. Some jobs were videotaped to obtain an overview of the plant layout and work activities, and to provide an opportunity for subsequent analysis of jobs if necessary.

Employee Interviews

We conducted confidential interviews with 11 workers. Management provided the NIOSH team with an alphabetized list of workers from both the front axle and rear axle assembly areas. Workers were randomly selected for interview from both production areas. Workers were asked to describe their job, how long they had worked for ZF Industries and any personal illnesses or injuries they attributed to work at the assembly plant. OSHA 300 logs for the years 2002-2004 were also reviewed.

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.[1,2,3,4] The risk of injury appears to increase as the intensity and duration of exposures to these factors increases and the recovery time is reduced.[5] Although personal factors (e.g., age, gender, weight, fitness) may affect an individual's susceptibility to

overexertion injuries/disorders, studies conducted in high-risk industries show that the risk associated with personal factors is small compared to that associated with occupational exposures.[6]

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

RESULTS

Ergonomics

The primary risk factors for the development of WMSDs that we observed are the lifting and carrying of parts and the bent back postures required due to the improper or incomplete parts delivery systems at many work stations. The need to continue production while reconfiguring the work cells has resulted in many instances where workers unload parts from pallets and walk to containers situated far from the immediate work area to retrieve parts. Carrying parts long distances occurs primarily when more than one type of part could be specified by the assembly plant, e.g., front end differentials. (As many as 90 different axle configurations could be produced by ZF Industries given the number of variations that exist among the components that comprise the front and rear axles.) There is not enough room in the assembly areas for all the different parts, so workers must retrieve them from separate bins when the specification changes. The solution is to have different specification parts sequenced in a single bin that can be located conveniently in the work station, but this is not yet in place. In some instances, workers place parts on racks or in bins that feed directly to the assembly line in the proper order, but this requires lifting and handling the parts twice. The type of parts bin that is used, but not yet deployed at all work stations, is called CREFORM® . A material handling system, CREFORM consists of plastic-coated steel pipes, fittings, and accessories that enable adaptation of versatile material handling structures to a variety of parts delivery applications.

"Clicking," a common work practice, adds to the physical load of workers. Even though most work stations are equipped with high-tech automatic torque wrenches, Mercedes-Benz requires that ZF Industries manually check each assembly for proper specification. The check is performed by attaching a torque wrench to a nut or bolt and measuring how tightly it is fastened ("clicking"). Some of the torque wrenches used are large and heavy and require awkward arm and shoulder postures to position them correctly on the axle assembly.

Employee Interviews

Of the 11 workers interviewed, seven were employed on the rear assembly and four on the front assembly lines. Ten reported one or more musculoskeletal injuries (four workers reported wrist and arm strain, three reported neck and shoulder strain, and two workers had low back injuries). Each of the workers reported that these injuries were sustained while working the old assembly configuration and were not the result of current work conditions. Approximately half of the workers interviewed were concerned that the current assembly line was constructed too low for sustained comfort. These workers reported low back muscular fatigue that resolved upon leaving work in the evening.

ZF Industries Incident Report Logs

We reviewed the ZF Industries safety incident report logs (OSHA 300) for years 2002 through 2004. ZF Industries had 46 recordable injuries in 2002, 23 in 2003, and 25 in 2004. A tabulation of all injuries sustained during this period showed muscle strain the most common injury type for the 3 years reviewed, and hand/arm as the most likely injury location followed by finger and back.

Worker Safety Concerns

A number of safety concerns were raised during the interviews. Notably, workers reported there were no clear traffic lanes for forklift drivers. Without clear traffic lanes, employees were in danger of being hit by fast moving forklifts. Additionally, pallets of materials delivered by forklift to the workstation often have to be repositioned manually by the workers. Workers reported that this practice increased their risk of back injury.

Workers were also concerned that BPSIs had not been computed for the new jobs. According to the company, the reason is that some jobs are not yet fully configured. However, some workers reported that they are tired of waiting and will not be convinced that the new jobs are safe until the BPSI computations are completed.

Workers reported that they are not given adequate or complete information when inquiries are made regarding the status of job changes or refinements, such as installation of proper dunnage for certain operations. Workers were also concerned with overtime. Even in cases where workers agree to the additional hours, which is typical, there is concern that the desired total for BPSIs in a daily rotation is exceeded if the workers go through the cell rotation more than once, particularly if the jobs with the higher BPSI rating are repeated more than once.

DISCUSSION

ZF Industries is a fairly new company that has undergone extensive change during its short history. In 1999 the company had an injury incidence rate of 42 per 100,000 work hours and paid about $500,000 in workers' compensation. At the end of 2004, through job evaluation, design efforts by consultants, and increased employee training, injury incidence rates were below 10 per 100,000 work hours and workers' compensation was reduced by 82% to $90,000. This downward trend is commendable, but because the company is going through change, improvements in work methods and job configuration need to occur if these reduced costs are to be sustained.

The company plans to improve dunnage (a collective term for the containers, pallets, and boxes parts are shipped in) and the delivery of assembly parts to workers. These improvements should reduce unnecessary parts handling and the postural load associated with manually lifting parts from the floor and from stacked pallets. However, unless these changes occur in a timely fashion, particularly as production rates increase to projected goals, workers will likely sustain injuries. Progress toward these goals has been frustrating for workers and for ZF Industries management. In some cases specification and production changes made by Mercedes-Benz have caused delays. Clear and realistic communication between workers and management may ease any distrust or resentment regarding the timetable for completing the assembly line transformations.

Another scheduled change that will improve the health and safety of workers is the reduction in forklift traffic by converting to a tugger style of parts delivery. Tuggers are mechanized vehicles that carry small numbers of parts directly to the assembly workstations, eliminating the clutter of large pallets and bins of parts placed on the floor in assembly areas. This method will require more logistic workers (material handlers) because parts will be delivered more frequently to the assembly cells. However, clutter and congestion in the plant are expected to decrease. Furthermore, plant traffic will be safer because tuggers move more slowly through the plant than forklift trucks. The company expects to increase logistic workers from 12 to 29, but the success of this method depends on the completion of the customized racks and conveyor systems to which parts are delivered.

It is reasonable that the company has not completed the BPSI calculation for jobs in the new "just in time" and cell work arrangements still being phased into place. Likewise, it is understandable that workers are concerned that they might be at risk of injury because the sum total of BPSIs in a particular cell is not known, particularly because many employees are

working overtime and rotating to certain jobs more often than intended. Increases in production rate will also add to the exposure of workers, making the timely calculation of BPSIs on these new jobs even more important to ensure that workers do not exceed intended safe work levels.

Due to the chassis assembly height for the front and rear axles, the moving conveyor is lower than the standard 27-31 inches. However, in some instances workers must bend over, particularly if their job involves performing an operation on a low part of the chassis. Low conveyor height was an issue reported by workers, so it may be that at some work stations the position of the work piece should be modified. A tall worker placing rotors on a rear axle assembly was observed to bend over to position the part on the hub. Completion of the BPSI determinations for the new axle lines should identify this and other jobs with excessive body posture requirements.

When the new line of axles began production, Mercedes-Benz required that the first 5000 axles be checked manually ("clicked") for torque specification. ZF Industries thought it had satisfied the requirement, but a technical difficulty on one assembly resulted in Mercedes-Benz specifying checking an additional 5000 assemblies with a manual torque wrench. Eventually, this added step will be eliminated, which will reduce the workload of many of the production employees.

CONCLUSIONS

1. The ergonomics approach used by ZF Industries (both internal and through consulting services) to design and evaluate jobs is sound and, when fully implemented, should lead to a safer workplace.

2. Until the parts delivery system is implemented, planned job modifications occur, and rotational positions are configured based on acceptable levels of cumulative BPSIs, workers may get injured as production increases to projected goals.

3. Better communication between management and workers regarding the status of assembly line and job transformations would enable the plant to function more smoothly as the transition to the new axle nears completion.

RECOMMENDATIONS

1. Install parts delivery systems for each work station so that workers can complete their job cycle tasks without walking to distant parts bins or pallets, carrying parts to the work area, or bending over to lift parts from the floor or from pallets.
2. Continue installation of custom lift assist devices for all parts weighing more than 25 pounds to reduce awkward postures and heavy lifting from containers and from pallets.
3. Complete the BPSI calculations for all new jobs so that unacceptable body postures and excessive muscular effort requirements can be identified and remedied. Timely arrangement of rotational patterns to coincide with the cumulative BPSI limits will ensure that reductions in lost time injuries will continue.
4. Improve communication between management and workers regarding the progress of planned implementation of job changes and stress level calculations for the jobs on the new lines. This can be accomplished by scheduling more meetings among workers and managers or through written postings in newsletters or on bulletin boards.

REFERENCES

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

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

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

4. NIOSH [1997]. Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, (DHHS) Publication No. 97-141.

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

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

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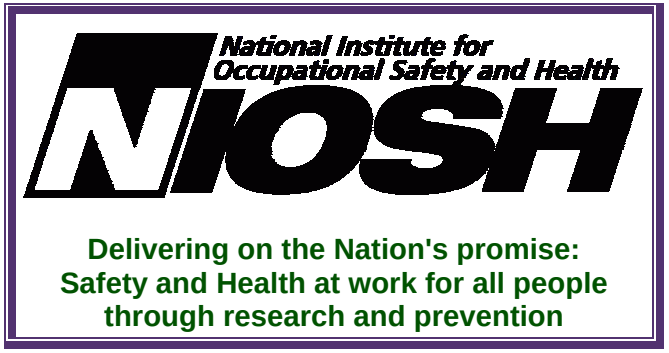

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