ERGONOMIC INTERVENTIONS AND INNOVATIONS FOR THE MARITIME INDUSTRIES

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Abstract

Many of the job processes being performed at ship construction, repair, and recycling yards today do not significantly differ from those same processes as seen fifty years ago. Individual workers still use stick welding equipment to connect subassemblies into bigger blocks or units. Workers enter confined spaces and assume awkward postures to complete welding, wiring, piping, electrical or insulation tasks. The complexity of the vessels may have increased over fifty years but many of the job processes have not kept pace with changes in technology. Due in part to the mismatch in technology between work processes and product design, researchers at the National Institute for Occupational Safety and Health (NIOSH) conducted a series of ergonomic interventions at a number of domestic shipyards. These interventions addressed those processes linked to the most numerous or most severe chronic musculoskeletal disorders among the maritime production work force.

Introduction

Relatively few major innovations have occurred in the shipbuilding and repair industries over the past 50 years, since the process of welding steel components together became common practice in ship construction and repair. In fact, individual workers still use stick welding equipment to tack structural components together in many shipyards. The advent of wire welding equipment has reduced the amount of stick welding being performed in shipyards. In many yards, underwater plasma-arc cutting is utilized to smoothly cut steel plate into intricate subassembly shapes. This process minimizes the amount of grinding that must be performed prior to fitting components together.

Even with innovations such as those mentioned above, the domestic ship construction, repair, and recycling industries in the United States of America have historically had much higher injury incidence rates than those of general industry, manufacturing, or construction. For 1998, the last year available, the U.S. Bureau of Labor Statistics reported that the shipbuilding and repair sector had a recordable injury rate of 22.4 per 100 full-time employees (FTE). By contrast, in 1998, the manufacturing sector reported a rate of 9.7 per 100 FTE, construction reported a rate of 8.8 per 100 FTE, and general industry reported a rate of 6.7 injuries per 100 FTE. When considering injuries resulting in days away from work, for 1998, shipbuilding and repair had an incidence rate of 11.5 per 100 FTE, compared to manufacturing at 4.7, construction at 4.0, and general industry at 3.1 injuries per 100 FTE.

When one considers which part of the workers' body is being injured, resulting in days away from work, shipbuilding and repair is significantly different from the manufacturing industry. For the year 1997, the most recent data available, for injuries to the trunk, including the back and shoulders, shipbuilding and repair reported an incidence rate of 207.7 cases per 10,000 FTE, compared to manufacturing at 82.1 cases. For injuries solely to the back, shipbuilding and repair reported an incidence rate of 111.1 cases per 10,000 FTE, compared to manufacturing at 52.2 cases. For the lower extremity, shipbuilding and repair reported 145.0 cases per 10,000 FTE, compared to manufacturing at 40.8 cases. When type or nature of injury resulting in days away from work is considered, shipbuilding and repair again significantly differs from the manufacturing industry. Again, for 1997, for sprains and strains, shipbuilding and repair reported 237.9 cases per 10,000 FTE, compared to 91.0 for manufacturing. The median number of days away from work for shipbuilding and repair is 12 days, compared to manufacturing's median of 5 days.

Beginning in 1995, the National Shipbuilding Research Program funded a project looking at the implementation of ergonomic interventions at a domestic ship construction yard as a way to reduce injured worker costs and to improve the productivity for targeted processes. That project came to the attention of the Maritime Advisory Committee for Occupational Safety and Health, a standing advisory committee to the Occupational Safety and Health Administration of the U.S. Department of Labor. In 1997, NIOSH began a project looking at ergonomic interventions in other ship construction yards. In 1998, the U.S. Navy funded a number of research projects looking to improve the commercial viability of domestic shipyards as a way to maintain the trained labor pool in case the Navy saw need to expand rapidly. Researchers at NIOSH successfully competed in that project selection process.

Methodology

Numerous walkthrough surveys were conducted at domestic shipyards to solicit candidate yard participation and to develop qualitative risk factor assessments of the industry. Seven shipyards were selected for participation based on a number of factors including: type of work being performed, type of product, geographic distribution, employment size, willingness to share records, and having an interest in developing ergonomic interventions. The injury databases for the selected yards were examined for the years 1994 to 1999 to identify high risk departments, jobs, or processes and to establish a baseline to assess the effectiveness of future intervention efforts.

Pre-intervention quantitative risk factor analyses were conducted at participating yards focusing on processes identified as high-risk. A variety of exposure assessment techniques were implemented where deemed appropriate to the process being analyzed. These exposure assessment techniques provide a means to quantify the risk factors associated with how the processes were originally executed. The same exposure assessment techniques are used after ergonomic interventions have been implemented to again quantify the risks associated with how the modified process is executed. A reduction in risk factors suggests that the modified process is less stressful on the worker and should result in a decrease in musculoskeletal complaints, as well as an increase in productivity.

Ergonomic Intervention Cost Justification

The effectiveness of any ergonomic intervention does not necessarily correlate with the cost of implementing that intervention. The possibility exists for a very effective intervention to be found at a low implementation cost. However, the opposite is also possible. The preferred intervention strategy from a business sense is to implement those interventions with the lowest costs and the highest effectiveness.

There are a number of benefits that can be credited to the application of ergonomic interventions in general[1]. These benefits are listed below.

- Avoidance of current expenses and ongoing losses
  - Reducing worker injury costs
  - Overtime for replacement workers
  - Lost productivity, quality or yields from less skilled workers
  - Increased training and supervisory time
- Enhanced existing performance
  - Increased productivity including fewer bottlenecks in production, higher output, fewer missed delivery dates, less overtime, labor reductions, and better line balancing
  - Improved quality including fewer critical operations, more tasks with every operator's control and capacity, and fewer assembly errors
  - Increased operating uptime including faster setups, fewer operating malfunctions, and less operator lag time.
  - Faster maintenance including increased access, faster part replacement, fewer tools needed, more appropriate tools, more power and faster tool speeds.
- Enhanced quality of worklife
  - Less turnover
  - Less employee dissatisfaction
- Fewer traumatic injuries
- Fewer human errors resulting in lost product or operating incidents
- Reduced design and acquisition costs

Another aspect of ergonomic interventions that must be considered is the cost benefit analysis. If total costs outweigh all benefits received from implementing the intervention, then the intervention is not worth undertaking. One has to determine the associated start-up costs, recurring costs, and salvage costs of the intervention as well as the time value of money (present worth versus future worth) and the company's Minimum Attractive Rate of Return, the interest rate the company is willing to accept for any project requiring financial commitment.

Example of an Implemented Ergonomic Intervention

The ship's door facility within a major U.S. shipbuilding operation was redesigned to reduce the high number of lower back injuries occurring due to manual materials handling tasks. The injury incidence rate prior to the ergonomic interventions and redesign of the facility were approximately 40 injuries per 100 FTE within the ship's door facility. The injury incidence rate for the rest of the facility was about 7 injuries per 100 FTE.

An ergonomics committee was formed for the project comprised of ergonomics-trained individuals, an occupational health nurse, the area supervisor, the work group leaders and the shop-floor workers. The ergonomics committee met on a weekly basis in facilitated meetings where brainstorming and idea documentation was crucial. This committee analyzed all pertinent injury and production data looking for trends in the data. The committee performed job site analyses of the high injury areas of the door shop. These analyses included employee interviews, a review of work methods, and the flow of material through the work process.

The committee determined that the ship's door facility had limited mechanical means to handle heavy and bulky products resulting in a high occurrence of manual materials handling. The actual design of the facility limited the addition of mechanical lifting devices due to the physical design of the shop's building. Relatively low ceilings, a limited floor capacity due to a floor made of wood and a narrow aisle width precluded the installation of mechanical lifting devices within the current building. It was determined that moving the door shop to another available building may allow for the installation of mechanical lifting devices as well as a redesign of the process flow.

A simple cost-benefit analysis was conducted to determine the economic feasibility of moving the ship's door operation to a neighboring building that was being used as a warehouse. Cost savings were identified for both man-hour and injury components and compared to the cost of implementing the move the new facility. The cost of moving to the new facility was estimated to be about $94,000. The annual projected savings were estimated to be about $107,000 resulting in a benefit to cost ratio of 1.14. Therefore the project would pay for itself within the first year of implementation.

The company approved capital funding for the project. The facility was moved to a larger building that had mechanical lifting devices installed to minimize manual materials handling of the ship's doors and components. Since the move to the new location, the incidence rate for lost time back injuries has dropped from 7.75 per 100 FTE to 1.2 per 100 FTE. The number of overall injuries decreased about 60 percent and the severity of injuries has decreased. General worker attitudes within the ship's door facility have improved. The absenteeism rate within this operation has also improved. Prior to the implementation of this intervention, door fabrication took approximately 40 labor hours. With mechanical lifting devices and the new facility layout, productivity initially improved 20 percent with door fabrication taking 32 labor hours per unit. This resulted in a savings of about 2,600 labor hours, or about $45,000, per year. Due to additional ergonomic interventions the following year, labor hours per unit were decreased to 28 hours, while at the same time increasing the overall scope of work. This additional increase in overall efficiency resulted in savings of 4,138 labor hours, or about $74,493, per year.

Ongoing Ergonomic Interventions

Other ergonomic interventions are currently being implemented in a number of domestic shipyards. These interventions include: 1) the installation of lift tables at shear press operations in a plate shop, 2) ergonomics awareness training at a ship repair facility, 3) the development of prototype cable pulling aids, 4) the accumulation of vibration analysis data from common powered hand tools used in the shipyards, and 5) the development of "best industrial practices" for confined space welding tasks and other shipyard tasks. Each of these interventions is focused on the mitigation of musculoskeletal injury risk factors associated with specific shipyard work processes which tend to result in the most common, most severe or most costly musculoskeletal injuries.

Conclusions

It has been shown in a number of different industries that implementation of ergonomic interventions can be a cost-effective measure to reduce worker injuries and associated costs, while improving productivity and product quality[2,3,4]. Shipyard industries, despite the ever-changing and harsh work environments, may benefit from ergonomic interventions as well. The current project is aimed at identifying those ergonomic interventions that have or can be implemented in ship construction, repair or recycling yards as a means of reducing worker injury costs and improving productivity and product quality.

Bibliography

[1] Alexander, D. C. 1998. Strategies for cost justifying ergonomic improvements. *IIE Solutions*, vol. 30, no. 3, 30-35.

[2] Gjessing C. G., Schoenborn T. F., Cohen A., eds. 1994. *Participatory Ergonomic Interventions in Meatpacking Plants.* 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. 94–124.

[3] Alexander, D. C. 1998. *Applied Ergonomics Case Studies 1998.* Engineering and Management Press.

[4] Alexander, D. C. 1999. *Applied Ergonomics Case Studies 1999.* Engineering and Management Press.

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