INTERIM SURVEY REPORT:

RECOMMENDATIONS FOR ERGONOMICS

INTERVENTIONS FOR SHIP CONSTRUCTION PROCESSES

at

HALTER MOSS POINT SHIPYARD
MOSS POINT, MISSISSIPPI

REPORT WRITTEN BY:
Steven J. Wurzelbacher, Industrial Hygienist
Stephen D. Hudock, Safety Engineer
Ova E. Johnston, Engineering Technician

REPORT DATE:
August 2001

REPORT NO.:
EPHB 229-12b

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Division of Applied Research and Technology
Engineering and Physical Hazards Branch
4676 Columbia Parkway, Mailstop R-5
Cincinnati, Ohio 45226

PLANT SURVEYED:	Halter Moss Point Shipyard, Halter Marine Group, Inc. Moss Point, Mississippi.
SIC CODE:	3731
SURVEY DATE:	November 29-30, 1999
SURVEY CONDUCTED BY:	Stephen D. Hudock, Safety Engineer Steven J. Wurzelbacher, Industrial Hygienist
EMPLOYER REPRESENTATIVES:	Mike Davis, Corporate Safety Director (504-248-2236) Bobby Howell, Plant Manager Halter Moss Point Shipyard Bill Williams, Process Improvement Team (228-474-5830) Jake Winstead, ABC Process Improvement Team Corporate (228-493-6053) Emerald Smith, Safety Manager, Moss Point Division (228-475-1211) Bob Dearth, Safety / Environmental Manager (228-475-1211)
EMPLOYEE REPRESENTATIVES CONTACTED:	Not applicable, non-union facility
MANUSCRIPT PREPARED BY:	Diana R. Flaherty

DISCLAIMER

Mention of company names and/or products does not constitute endorsement by the Centers for Disease Control and Prevention (CDC).

ABSTRACT

A pre-intervention quantitative risk factor analysis was performed at various shops and locations within Halter Marine, Inc. Moss Point Shipyard, as a method to identify and quantify ergonomic risk factors that workers may be exposed to in the course of their normal work duties. The application of exposure assessment techniques provided a quantitative analysis of the risk factors associated with the individual tasks. Based on these analyses and a review of safety management practices, three ergonomic interventions are suggested for the Halter Marine Shipyard:1) a computerized injury tracking system for use in the Halter safety, workers compensation, and administative departments, 2) a shear press lift table for the east side fabrication shop, and 3) a gator bar tool re-design for the angle iron positioning process in the steel yard. Detailed descriptions of each intervention are provided including cost benefit analysis where appropriate.

I. INTRODUCTION

IA. BACKGROUND FOR CONTROL TECHNOLOGY STUDIES

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency in occupational safety and health research. Located in the Department of Health and Human Services, it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposures to potential chemical and physical hazards. The Engineering and Physical Hazards Branch (EPHB) of the Division of Applied Research and Technology has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, NIOSH has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

These studies involve a number of steps or phases. Initially, a series of walk-through surveys is conducted to select plants or processes with effective and potentially transferable control concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

IB. BACKGROUND FOR THIS STUDY

The background for this study may be found in the previous report no. 229-12a, “Preliminary Survey Report: Pre-Intervention Quantitative Risk Factor Analysis for Ship Construction Processes at Halter Moss Point Shipyard, Moss Point Mississippi” by Hudock et al, 2000.

IC. BACKGROUND FOR THIS SURVEY

Halter Marine, Inc. Moss Point Shipyard was selected for a number of reasons. It was decided that the project should look at a variety of yards based on product, processes and location. Halter Marine, Inc. is the “nation’s leading commercial shipbuilder” and is one of the top builders in the world of mid-sized ocean going vessels. Halter Marine, Inc. has a number of shipyards along the Gulf Coast that differ in work process and product. Some of the Halter yards focus on new construction, others on repair services. Some of the Halter yards specialize in oil rig construction, others in vessel construction.

All of Halter's yards are considered to be medium- to small-size yards. Halter Marine, Inc. is a member of the Shipbuilders Council of America..

II. PLANT AND PROCESS DESCRIPTION

IIA. INTRODUCTION

Plant Description: The Halter Moss Point shipyard is located in Moss Point Mississippi. The facility consists of approximately 58 acres of property with 61,500 square feet of shops, offices and warehouses and 60,165 square feet of outside concrete construction platforms. The facility has six crawlers cranes and six track mounted gantry cranes. The yard has the capacity to build vessels up to 400 foot length 85 foot beam, 18 foot water depth, and 85 foot height . At the time of the site visit, three off-shore service vessels (OSV's) for the Gulf oil drilling industry were in various stages of construction. Also, a special-purpose vessel for the U.S. National Aeronautics and Space Administration was under construction. This vessel will be used for the recovery of the space shuttle rocket boosters after each launch of the shuttle.

Corporate Ties: Halter Marine, Inc., a company of Friede Goldman Halter.

Products: Halter Marine, Inc. produces offshore supply vessels for the oil drilling industry, ocean-going tank barges and tug boats, excursion and gaming vessels, oceanographic and hydrographic research ships, logistic support vessels, and various small military interdiction craft.

Age of Plant: Halter Marine Moss Point yard has been functioning as a shipyard since 1993.

Number of Employees, etc: The Moss Point shipyard, as of the date of the survey, had 416 full-time Halter employees and 174 contract workers on site. Prior to 1997, there were fewer than 50 contract workers within the yard. In 1998, a new contractor was hired and, in general, fills the less-skilled production positions. Average annual employment historically has been approximately 400 workers.

IIB. SELECTED PROCESS DESCRIPTIONS

IIB1. Angle Iron Positioning by Gator Bar Worker in Steelyard

Figure 1. Gator Bar Worker in Steelyard

Prior to use in any sub-assembly, the raw steel stock must be blasted to remove rust or other residual material on the surface of the steel. Angle irons are delivered to the spraying platform in bundles by a mobile crane. The angle irons are dropped onto the platform and are then positioned across the platform as necessary by the gator bar worker and helper.

Figure 2. Gator Bar Worker Positioning Angle Iron

Figure 3. Gator Bar Worker Flipping Angle Iron from Side with Gator Bar

Figure 4. Gator Bar Worker Flipping Angle Iron from End with Hands

The most common trades employed as gator bar workers are shipfitters and blasters. Angle irons are adjusted into place by the gator bar worker using their hands or gator pry bar to grip the angle irons. While positioning and flipping angle irons for abrasive blasting, the gator bar worker experiences a number of ergonomic risk factors. These risk factors include awkward postures such as extreme lumbar flexion, as well as excessive loads to low back and shoulders.

IIB2. East Side Fabrication Shop Shear Operation

Figure 5. Shear Operator Placing Steel Plate on Shear

The primary process for the shear operator is to cut steel plate to various dimensions as required for hulls and subassemblies. The particular process flow for the shear is as follows:

1) raw plates are moved from pallets to the shear by jib crane that sits between stations
2) long plates are laid across an array of roller bearing supports to hold weight of plate while being sheared, and
3) cut plates are dropped at the back of the shear onto a sloped tray that reaches to ground level. Smaller pieces may not slide to the bottom of the tray and must be hooked and slid to the bottom by the shear operator,

Figure 6. Shear Operator Hooking Small Cut Pieces

4) cut plates are either manually lifted or lifted by jib crane and placed into containers.

Figure 7. Shear Operator Lifting Pieces at Back of Shear

Figure 8. Shear Operator Using Jib Crane to Lift Cut Plate

The most common trades working as shear operators are machinists and shipfitters. Shear operators often lift awkward loads from the ground-level shear chutes and material supply pallets. Contact stresses experienced by the shear operator include kneeling on the floor to get material and contact with the sharp edges of the raw or cut material.

III. ERGONOMIC INTERVENTION COST JUSTIFICATION

The following section has been adapted from the article by Alexander, 1998.

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, as well as, the possibility of the opposite. The preferred intervention strategy from a business sense is to implement those interventions with the lowest costs and the highest effectiveness. This point can be illustrated by the value/cost matrix as illustrated in Figure 9.

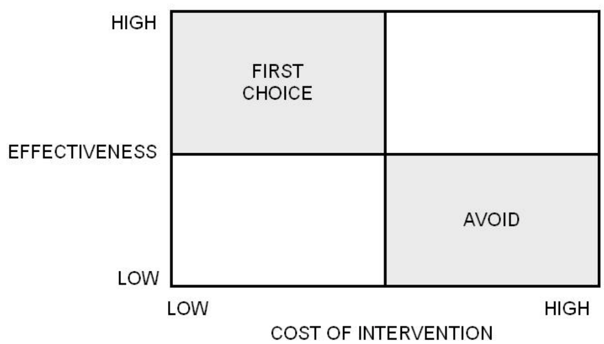

Figure 9: Value Cost Matrix

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

- Avoidance of current expenses and ongoing losses, including:
  - – Workers compensation costs
  - – Overtime for replacement workers
  - – Lost productivity, quality or yields from less skilled worker
  - – 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.

In addition to the direct medical costs associated with worker injuries, one must also consider the indirect or hidden costs associated with the primary worker being away from their job. These indirect costs are listed below.

- Costs of replacement workers
  - Hiring costs for permanent replacements plus training and other costs
  - Additional costs for temporary workers who may also have lower work skills

- Lower productivity
  - Fewer units per hour
  - Lower yields
  - Damage to material or equipment that would not occur with an experienced worker

- Lower quality
  - Number of rejects
  - Amount of rework
  - Timeliness of product delivery

- Increased supervision
  - Cost to manage/train a less skilled worker

- Training to develop and maintain job skills
  - Amount of lost work time
  - Time of trainer.

Many of these indirect costs are difficult to estimate and can vary widely depending on the severity of the injury involved. The ratio of indirect costs to direct costs has also been found by a number of studies to vary between 5:1 to 1:5, depending on industry (Heinrich, 1931, 1959; Levitt et al, 1981; Andreoni, 1986; Leopold and Leonard, 1987; Klen, 1989; Hinze and Applegate, 1991; Oxenburgh, 1991, 1993). As a conservative estimate, the state of Washington recently decided upon indirect costs of 75 percent of direct workers' compensation incurred costs (WAC 296-62-051, 2000).

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 of financial undertaking.

IV. CONTROL TECHNOLOGY

The following section presents various ergonomic interventions that are recommended for implementation in the Halter Moss Point yard. These recommendations are based on the risk factor analysis and a review of safety management practices that was performed at Halter in November of 1999 and detailed in a previous NIOSH report (No. 229-12a).

IVA . INJURY TRACKING SYSTEM INTERVENTION FOR USE IN THE SAFETY, WORKERS COMPENSATION, AND PRODUCTION HOUR REPORTING DEPARTMENTS

Developing cost justifications for ergonomic interventions at halter is difficult due to the fact that the current injury database collects only OSHA 200 information and includes only a breakdown of production hours for the total yard .Thus, the foremost recommended intervention is the utilization of a new injury tracking system that will enable such justifications. The reduction of musculoskeletal injuries throughout the Halter Moss Point yard can be greatly facilitated by the implementation of a computerized injury tracking system that integrates safety data workers compensation data, and production hour reporting and which is also based on the bureau of Labor Statistics (BLS) injury reporting method. Since 1992, BLS has collected detailed information on the characteristics of lost- work time cases and the traits of workers sustaining such injuries and illnesses. In addition to the information required for OSHA 200 logs, the BLS system collects the following data:

Table 1: Bureau of Labor Statistics Database Summary (information adapted from Chapter 9, Occupational Safety and Health Statistics, BLS Handbook of Methods)
Employee Data
• Approximate length of service at establishment when the incident occurred
• Employees race or ethnic background (optional)
• Employee's age or date of birth
• Employee's sex
Incident Data
• NATURE: Nature of injury or illness names the principal physical characteristic of a disabling condition, such as sprain/strain, cut/laceration, or carpal tunnel syndrome.
• PART OF BODY: Part of body affected is directly linked to the nature of injury or illness cited, for example, back sprain, finger cut, or wrist and carpal tunnel syndrome.
• SOURCE: Source of injury or illness is the object, substance, exposure, or bodily motion that directly produced or inflicted the disabling condition cited. Examples are a heavy box, a toxic substance, fire/flame, and bodily motion of the injured/ill worker.
• EVENT: Event or exposure signifies the manner in which the injury or illness was produced or inflicted, for example, overexertion while lifting or fall from ladder.

The collection of these additional types of data for every injury and illness improves the ability of a safety team to track problem occupational tasks within the yard that pose excessive risk for not only musculoskeletal disorders, but all injuries in general. The data can also be used for comparison against published BLS rates for the shipbuilding and repair industry (SIC Code 3731) to further monitor the yard's progress. Once individual safety personnel have been properly trained, the additional time to collect these data becomes minimal.

The next step is to establish a communications link between the worker's compensation and production hour reporting databases at Halter and the new injury database so that incidence rates and costs per production hour can be calculated for individual departments. At a minimum, production hours should be provided to the safety department at least monthly and updated medical costs should be provided on a regular basis until approximately two years after the date of initial injury. If possible, the computer systems within the yard should be integrated to provide continual updating of this information.

The following table lists the key aspects of this recommended intervention, including deliverables:

Table 2: Recommended Injury Tracking System Intervention
• A computerized injury tracking database (based in Microsoft Access or Excel) utilizing the Bureau of Labor Statistics (BLS) injury reporting method will be customized for use at Halter Moss Point by NIOSH. No commercial software versions are currently available, but similar systems that facilitate the collection of general health and safety data (e.g. OSHA 200 logs) are priced from $200-1000.
• Training will be provided to Halter safety, worker's compensation, and production hour reporting personnel by NIOSH researchers on the collection and analysis of the safety data and linkage of this information through the yard.
• Halter safety personnel will be expected to utilize the system for a period of at least six months after the date of training so that the effectiveness of the database intervention can be evaluated by NIOSH researchers. This commitment is expected to require approximately two hours per week per individual or selected Halter personnel.

IVB. POSSIBLE INTERVENTION FOR THE EAST SIDE FABRICATION SHOP SHEAR OPERATION

The primary concern for the east side fabrication shop shear operator or helper is the constant bending at the waist or kneeling to pick up material from the back of the shear at floor level. One possible solution is to provide an adjustable lift table for the shear chute at the back of the machine, as seen in Figures 10 - 12.

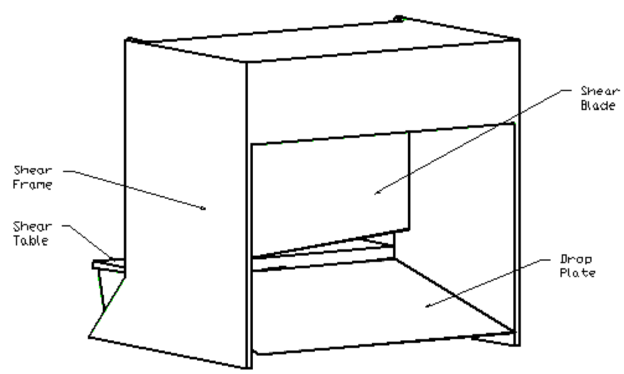

Figure 10: Oblique Rear View of Shear

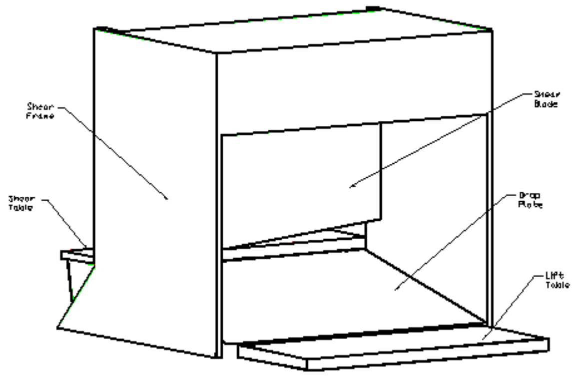

Figure 11: Shear with Lift Table in Down Position

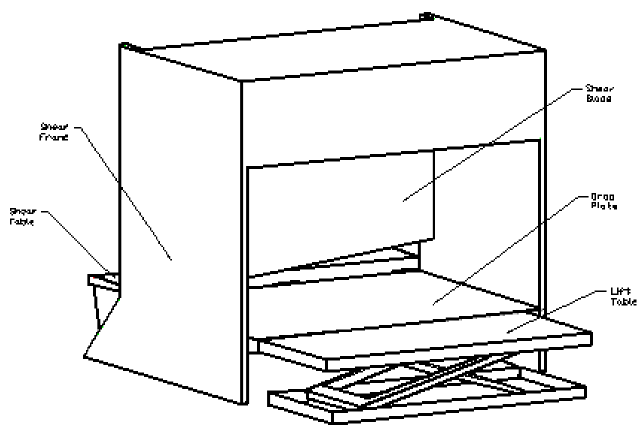

Figure 12: Shear with Lift Table in Up Position

By placing the edge of the rear chute on top of the lift table, one can greatly improve the process. In this way the cut material would still fall onto the back chute of the shear press. However, when the worker needs to remove material from the chute, the lift table can be elevated, raising the rear chute at the same time and allowing the worker to transfer cut material to the lift table at approximately waist height. This would eliminate the need for the worker to lift objects off the rear chute at near floor level. The rear chute plate weighs approximately 100 pounds and the weight of any material cut at any one time is under 300 pounds. It is suggested that a battery operated lift table be used to raise and lower material. Suggested approximate table characteristics are shown in Table 3. Approximate setup and training time with the table should be approximately 15 worker hours. At $20 per hour average wage, this amounts to an additional cost of $300. Total cost for the lift table and the worker time is estimated to be $2,000.

Table 3: Approximate Shear Lift Table Characteristics	
Type of Table	*Wheeled Battery Powered Lift Table with Hand Pendant*
Capacity	1,500 pounds
Table Dimensions	24 inches x 48 inches
Vertical Travel	36 inches
Price	$1,700

In identifying benefits of the intervention, one can use the medical and indemnity cost estimates as shown in Table 4 to calculate direct costs.

Table 4: Estimated[1] Shipyard Direct Injury Costs for Musculoskeletal[2] Injuries (medical + indemnity) by Part of Body [1] Based on analysis of available participating shipyard compensation data from 1996 - 1998 [2] Does not include contusions or fractures	
Ankle(s)	$2,390
Arm(s), unspecified	$7,725
Back	$6,996
Elbow(s)	$4,691
Finger(s)	$735
Hand(s)	$6,857
Knee(s)	$7,472
Leg(s), unspecified	$849
Neck	$5,961
Shoulder(s)	$4,960
Wrist(s)	$3,925

Due to the fact that the current Halter injury database does not include specific information to link injuries to tasks, it is impossible to determine exactly how many musculoskeletal injuries have been attributable to the use of the east side fabrication shop shear. However, from 1993 to 1999 Halter experienced five back injuries to shipfitters resulting in a total estimated medical and indemnity cost of $34,980, based upon average costs by part of body injured. If the five injuries can be said to be due to the use of the shear, the average annual estimate direct cost (over the last seven years) for musculoskeletal injuries for this process is $4,997. If indirect costs are conservatively assumed to be 75% of the direct costs, the total cost of these injuries is $8,745. It is this amount that can be considered an "avoided cost" and, therefore, a benefit due to the implementation of the intervention. Assuming, the intervention fully eliminates such injuries, a simple benefit to cost ratio would be $8,745/$2,000 or 4.37. Since the benefit to cost ratio is greater than one, it is advantageous and cost-effective to implement the proposed intervention. However it is possible that only half of the estimated annual injury cost is saved each year. It is also possible that the lift table lasts at least two years. Assuming that the shipyard has a minimum attractive rate of return of 20 percent for any project cash outlay, one can still calculate a benefit to cost ratio by utilizing the following equation to determine the present worth of an annual savings:

Equation 1: $$PW = AS \times \frac{\left[(1+i)^n - 1\right]}{i \times (1+i)^n}$$

where *PW* = present worth
AS = annual savings
i = interest rate (ex., 0.20 for 20 percent)
and *n* = number of years.

Using an annual savings of just $4,372 (half of the estimated annual injury cost) at an interest rate of 20 percent over a two year period, the present worth of the proposed savings would be $6,680. Assuming initial costs of the lift table are $2,000 and negligible annual costs, the benefit to cost ratio of implementing this intervention is $6,680/$2,000 or 3.34, greater than one, and therefore still economically advantageous.

IVC. POSSIBLE INTERVENTIONS FOR THE STEELYARD ANGLE IRON POSITIONING PROCESS

The principal hazards associated with the angle iron positioning process are the excessive upper extremity force and flexed back posture required to invert and pull the angle irons using the current gator bar tool. Possible interventions include using a mobile crane to spread the stack of angle irons across the platform when dropped and automating some of the processes to eliminate the pulling of angle irons into position across the platform. The entire flipping area could also be placed on a lift table and raised when the angle irons needed to be inverted. The estimated cost of installing such a lift table (with a required load capacity of 4500 lbs) is provided below in Table 5.

Table 5: Cost Summary of Angle Iron Sorting Table Intervention	
Cost of Raw Materials	$650
Cost of Lift Table	$4,550
Cost of Labor	$400
Total Cost	$5,600

However, inexpensive and simple alterations to the gator bar tool may also reduce the amount of back flexion and effort required to separate and flip individual pieces of long angle irons. For reasons of cost-effectiveness, these tool changes are the principal recommended interventions for the angle positioning process. Suggested gator bar changes are provided below in Table 6.

Table 6: Summary of Gator Bar Re-Design Intervention
• reduce the weight of the tool by constructing the middle handle portion of a composite material or aluminum with a foam covering
• provide a third wedge opening on the tool to allow for further gripping options to minimize awkward postures (See Figure 13)
• provide perpendicular bars on the handle to allow for other leverage options
• *ESTIMATED COST: <$1000 materials and labor*

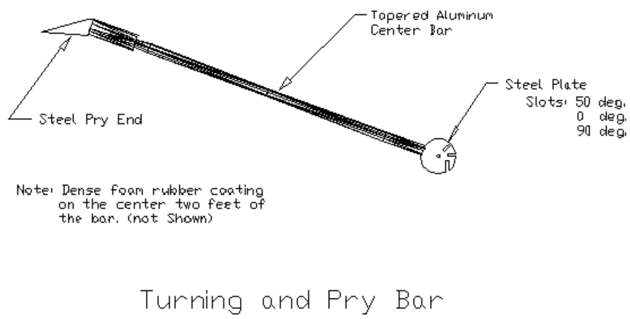

Figure13: Re-Designed Gator Bar

V. CONCLUSIONS AND RECOMMENDATIONS

Based on ergonomic task analyses and a review of safety management practices, three ergonomic interventions are suggested for the Halter Marine Shipyard: 1) A computerized injury tracking system for use in the Halter safety, workers compensation, and administrative departments, 2) a shear lift table for east side fabrication shop, and 3) a gator bar tool re-design for the angle iron positioning in the steel yard. Of these interventions, it is expected that the development of the injury tracking database will have the most effective impact on reducing musculoskeletal injuries, and therefore it is the most strongly recommended change.

The impact of any further ergonomic changes interventions cannot be fully assessed until such a tracking system is in place. However, the implementation of engineered ergonomic interventions has been found to reduce the amount and severity of musculoskeletal disorders within the working population in various industries. Therefore, it is recommended that the other suggested ergonomic interventions may also be implemented at Halter Marine Moss Point shipyard to minimize hazards in the identified job tasks.

Each of the interventions proposed in this document are to be considered preliminary concepts. Full engineering analyses by the participating shipyard are expected prior to the implementation of any particular suggested intervention concept to determine feasibility, both financially and engineering, as well as to identify potential safety considerations.

VI. REFERENCES

Alexander, D. C. Strategies for Cost Justifying Ergonomic Improvements. *IIE Soultions*, Institute of Industrial Engineers, Norcross, Georgia, March 1998, 30(3):30-35.

Andreoni, D. The Costs of Occupational Accidents and Diseases. Geneva: International Labor Office; 1986

Bureau of Labor Statistics Handbook of Methods, April 1997 web site edition.

Heinrich, H.W. Industrial Accident Prevention: A Scientific Approach. 4th Edition. New York: Wiley; 1959

Hinze, J. And Applegate, L.L. Costs of Construction Injuries. Journal of Construction Engineering and Management. 1991; 117(3): 537-550.

Hudock, S. D., S. J. Wurzelbacher, and O. E. Johnston. Preliminary Survey Report: Pre-Intervention Quantitative Risk Factor Analysis for Ship Construction Processes at Halter Moss Point Shipyard, Moss Point, Mississippi. DHHS, PHS, CDC, NIOSH, Cincinnati, Ohio, Report # EPHB 229-12a, May 2000.

Klen, T. Costs of Occupational Accidents in Forestry. Journal of Safety Research. 1989; 20(31):31-40.

Leopold, E. And Leonard, S. Costs of Construction Accidents to Employers. Journal of Occupational Accidents. 1987; 8:273-294.

Levitt, R.E. Improving Construction Safety Performance; 1982 Jan; Report A-3.

Oxenburgh, M. Increasing Productivity and Profit Through Health and Safety. Austrailia: CCH International; 1991

Oxenburgh, M.S. and Guldberg, H.H. The Economic and Health Effects on Introducing a Safe Manual Handling Code of Practice. International Journal of Industrial Ergonomics. 1993; 12:241-253.

Washington State Ergonomics Rule. WAC 296-62-051. (2000)