ERGONOMICS GUIDE FOR WELDERS

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All other requests for this document shall be referred to:
Cathy Rothwell, Navy Ergonomics Subject Matter Expert, NAVFAC Southwest Cathy.Rothwell@Navy.mil

Forward

This guide is for managers and supervisors at activities performing welding tasks. It provides a brief background on ergonomics and offers suggestions for improving the workplace to reduce the risk of work-related musculoskeletal injuries.

The United States Navy is committed to a healthy workforce. A healthy workforce helps ensure the highest level of operational readiness. Welding work contributes to a large percentage of injuries reported to the Naval Safety Center. Many of these injuries involve the musculoskeletal system and include strains or sprains to the lower back, shoulders and upper limbs. They can result in pain, disability, medical treatment, financial stress and a change in the quality of life for those affected with them. The cost to the Navy for an injury or illness decreases funds available for improving the overall workplace and ultimately decreases mission readiness.

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Introduction - What is Ergonomics?

Ergonomics has several meanings. The first is literal. Derived from two Greek words: *Ergo* = work; and *Nomos* = laws, ergonomics literally means *the laws of work*.

The practical meaning of Ergonomics is *fitting the task and work environment to the human*. Ergonomists try to design tasks and workplaces within the capability of the human. There are many examples of tasks, work environments, and even products, which did not take human capabilities into consideration.

For example, in your home, kitchen counter tops are usually about 36 inches in height. Is this a good height for everyone? No, it is usually too low for males and may or may not be correct for females (See Figure 1). The height was selected because it was the average elbow height for females in the 1930s. If counter tops were designed for the average male the height would be 43 inches. In a perfect ergonomic world, counter top height would be adjustable or there would be work surfaces at the proper height for your spouse, your children and yourself in kitchens.

Figure 1: Man and woman in the kitchen

Figure 2 : Awkward body posture

In the design of workplaces, human body size and capabilities must be considered. Injuries are more likely if task demands and the environment exceed the capabilities of the human. There are times when all ergonomics risk factors cannot be removed and the worker is exposed. Refer to Figure 2 where the worker is in an awkward posture while smoothing concrete. The goal is to limit the amount of time the person is in those less than adequate situations.

Think about how well your workplace accommodates you. Can you reach the items you use most without straining? Is it comfortable to lift the materials you need to move around? Are there handles to grasp the items or are they cumbersome and awkward? Can you change posture when you perform your work or are you in a static posture all day? These are just a few of the items that may indicate a mismatch between the workplace and the worker.

Most of the tasks welders perform are dictated by the design of the item being worked. In many cases, the materials are big, heavy, and might be covered with dirt, rust, and/or grime. However, there are numerous job aids such as fixtures, jigs, and part holders available to aid welders in doing their jobs and reduce the risk of injury. In addition, special chairs and/or creepers are available that provide body support while performing tasks so that an awkward posture is avoided. These types of ergonomic solutions will be presented in the following sections.

Physical Work Place Risk Factors:

The many possible causes of injury are not limited to one industry or to specific occupations, but result from a pattern of usage. Common causes of injury are:

- Repetitive gripping / twisting
- Repetitive reaching
- Repetitive moving
- Static postures
- Lack of rest to overcome fatigue

These causes fall into six major physical workplace risk factors:

- Force to perform the task
- Highly repetitive tasks
- Poor, awkward or static postures
- Pressure points or compression
- Vibration
- Duration

When present with sufficient frequency, magnitude, or in combination, these risk factors may cause Work-related Musculoskeletal Disorders (WMSDs). Musculoskeletal Disorders (MSDs) are injuries and illnesses that affect muscles, nerves, tendons, ligaments, joints, spinal discs, skin, subcutaneous tissues, blood vessels, and bones. WMSDs are:

- MSDs to which the work environment and the performance of work contribute significantly, or
- MSDs aggravated or prolonged by work conditions.

Additionally, environmental conditions such as working in temperature extremes may contribute to the development of WMSDs. Personal risk factors, such as physical conditioning, preexisting health problems, gender, age, work technique, hobbies and organizational factors (e.g., job autonomy, quotas, deadlines) may also contribute to, but do not cause, development of WMSDs.

Work Related Musculoskeletal Disorders

Many injuries can develop when there is a mismatch between the capabilities of the workforce and the demands of the task. These injuries are generally called **Work Related Musculoskeletal Disorders** (WMSD). These have also been called Cumulative Trauma Disorders (CTDs) or Repetitive Stress Injuries (RSIs)

In general, these conditions develop because of micro-traumas that occur to the body over time. Consider lower back vertebral disk degeneration. The vertebral disk (Figure 3) is made of flexible cartilage and contains a semi-liquid gel. The cartilage is in the form of rings. When a person performs lifts beyond their capability, these rings can degrade. If the person continues performing such lifts the disk can rupture. When it ruptures it bulges out and can place pressure on a spinal nerve causing severe pain.

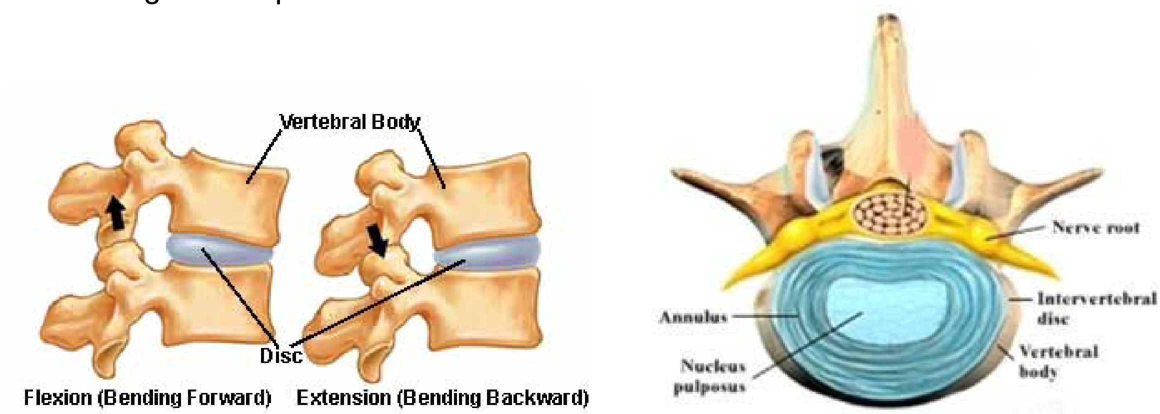

Figure 3: Spinal disc and vertebra

Common WMSDs for welders include:

Back Injuries – From strains and sprains to degradation of the vertebral disks
Bursitis – Inflammation of a saclike bodily cavity, containing a viscous lubricating fluid located between a tendon and a bone or at points of friction between moving structures (i.e. inflammation of a bursa)
Carpal Tunnel Syndrome – A complex disorder that starts with the inflammation of the tendon sheaths in the wrist and progresses into the degradation of median nerve
Tendonitis – Inflammation of the tendons
Tenosynovitis – Inflammation of tendon sheath
Thoracic Outlet Syndrome – A disorder in which blood vessels and nerves in the upper shoulder region are compressed and cause pain. This condition is sometimes caused by chronic postures associated with overhead work.
Trigger Finger – Tendons in the fingers “lock down” due to injury to the tendons

If you are experiencing signs / symptoms please contact your physician or occupational medicine clinic for an evaluation

Common Physical Workplace Risk Factors for Welders

Welding tasks may expose workers to physical workplace risk factors (or ergonomics stressors). If tasks are performed repeatedly over long periods of time, they can lead to fatigue, discomfort and injury. The main physical workplace risk factors (ergonomics stressors) associated with the development of a work-related musculoskeletal injury in welding tasks include:

- Awkward Body Postures
- Heavy Lifting
- Static Position

Applying proper ergonomic principles can reduce the potential for these and other WMSDs.

The Nature of Welding

Ask any professional welder and they will say that welding is a highly skilled profession that requires years to perfect. Welding is a precise task that requires the welder to maintain static postures for relatively long periods of time. In almost all cases welding in the field requires the welder to adapt to the workplace, rather than adapting the workplace to the welder. This is because metal is heavy and it is easier to have the welder assume an awkward posture, than move a ship. Welding also is hot work and generates metal fumes that can contain many relatively harmful metals.

The use of proven ergonomic principles can improve the way a particular task is performed, thereby reducing welder exposure to risk factors. This generally translates to a healthier workforce, improved morale, greater productivity and increased product quality. The Navy literally floats on quality welds.

Common welding postures

Ergonomics Stressors:
Compression: Leaning on a hard surface

Awkward & Static Posture: Holding the arms away from the body for long durations

Figure 4: Welding with the hands in front of the body

Welding with the hands in front of the body

Common welding postures

Ergonomics Stressors:
Compression: Leaning on a hard surface

Awkward & Static Posture: Back hunched forward

Figure 5: Welding at ground level

Welding at ground level

Common welding postures

Ergonomics Stressors:
Awkward & Static Posture: Extension of the neck, static loading in the arms and shoulders

Figure 6 Welding above shoulder height

Welding above shoulder height

<table>
<tr><th colspan="2">Common welding postures</th></tr>
<tr>
<td>Ergonomics Stressors:
Awkward & Static Posture: Hot work in a static posture caused by the constrained space

Compression: Leaning on a hard surface</td>
<td>
Figure 7: Welding in constrained spaces

Welding in constricted spaces</td>
</tr>
</table>

<table>
<tr><th colspan="2">Common welding postures</th></tr>
<tr>
<td>Ergonomics Stressors:
Awkward & Static Posture: Working with the back bent forward and wrist in extension

Compression: Leaning on a hard, sharp surface</td>
<td>

Figure 8: Welding with back bent forward

Welding with the back bent forward</td>
</tr>
</table>

<table>
<tr><th colspan="2">Common welding postures</th></tr>
<tr><td>Ergonomics Stressors:
Awkward & Static Posture: Working with the back bent forward

Compression: Kneeling on a hard surface</td><td>
Figure 9: Working with the back bent forward

Welding with the back bent forward</td></tr>
</table>

<table>
<tr><th colspan="2">Common welding postures</th></tr>
<tr><td>Ergonomics Stressors:
Awkward & Static Posture: Statically Holding a stooped forward posture</td><td>
Figure 10: Working in a stooped posture
Welding in a stooped posture</td></tr>
</table>

<table>
<tr><th colspan="2">Common welding postures</th></tr>
<tr><td>Ergonomics Stressors:
Awkward & Static Posture: Working with the back bent forward and holding the arms away from the body

Compression: Resting the arms on a hard surfaces</td><td>
Figure 11: Working with the back bent forward
Welding in constrained spaces</td></tr>
</table>

Implementing Solutions

The following section on ergonomic solutions for welders describes changes to equipment, work practices and procedures (administrative controls) that can address ergonomics-related risk factors, help control costs, and reduce employee turnover. These changes may also increase employee productivity and efficiency because they eliminate unnecessary movements and reduce heavy manual work.

The following resources recommend the use of engineering controls as the preferred method of dealing with ergonomics issues.

- Department of Defense Instruction Safety and Occupation Health Program (DoDI) 6055.1 Enclosure (6) DoD Ergonomic Program Requirements and Procedures, http://www.dtic.mil/whs/directives/corres/pdf/605501p.pdf

- Navy Safety and Occupational Heath (SOH) Program Manual (OPNAVINST 5100.23G), chapter 23, Ergonomics Program, http://www.safetycenter.navy.mil/instructions/index.asp

The recommended solutions in the following pages are not intended to cover all ergonomic challenges, nor is it expected that all of these solutions are applicable to each and every welding environment. It is recognized that implementing engineering solutions may present certain challenges, which includes work that is performed outdoors and in cramped spaces.

However, welding personnel are encouraged to use the examples in this document as a starting point for developing innovative solutions tailored to the specific ergonomic challenges. The solutions have been categorized according to the equipment type.

Many of the solutions presented were developed and funded by the Mishap Prevention and Hazard Abatement (MPHA) Program. For more information on the MPHA and no-cost ergonomics technical support services, go to the Ergonomics Page at http://www.navfac.navy.mil/safety

The following section was adapted from references 1 & 2:

Types of Ergonomics Improvement

Site Wide

Specialty Manual Material Handling Equipment

Description: Specialty equipment for welding material transportation

Advantage:

- Reduces pushing, pulling, lifting and carrying forces.
- Safer, saves time
- Carts, trucks, dollies can be customized

Points to Remember:

- Wheels should be appropriate for the flooring conditions
- Larger diameter wheels reduces push forces
- Wheels should be well maintained
- Ensure proper load capacity for equipment being moved
- Pushing is preferred over pulling


Figure 12: Gas cylinder transportation cart (left)
Figure 13: Gas safety / guardian transportation cart developed by the USAF houses cylinders, leads and hoses (right)


Figure 14: Gas cylinder transportation cart (left)
Figure 15: Panel cart for moving sheet metal and other long stock (right)

Reduce pushing, pulling, carrying and lifting forces

Storage and Handling Systems

Storage and Handling Systems

Description: Safety and health personnel recognized the ergonomics hazards associated with moving and carrying sheet metal and round stock and unnecessary preparation work due to outdoor storage conditions.

Project Summary and Advantages:

- A vertical index system virtually eliminates the manual handling storage and retrieval tasks. The storage system houses all the raw materials, and delivers it to the personnel around elbow height. Elbow height handling of material typically results in less back bending.
- The index system delivers the sheet metal quickly. Improves sheet metal quality and reduces handling time and unnecessary finish work because storage will be exclusively indoors and in one unified location.
- Saves time and effort when completing a project due to less preparation work through product specific storage and quicker product access time.
- Systems have inventory control functions to track stock in real time

Figure 16 Sheet metal storage, some of which was outdoors

Figure 17: Vertical sheet metal storage system used at New London, CT

Figure 18: Vertical sheet metal storage system

- Round stock system has security controls to limit access to level one stock and incorporates a grabbing claw and overhead hoist.

Points to Remember:

- Material index systems exist for material as small as medical supplies to as large as sheet metal.
- Jib cranes and clamps can be incorporated.

Figure 19: Before index unit, round stock retrieval was time consuming and required multiple pieces to be moved in order to locate the correct piece

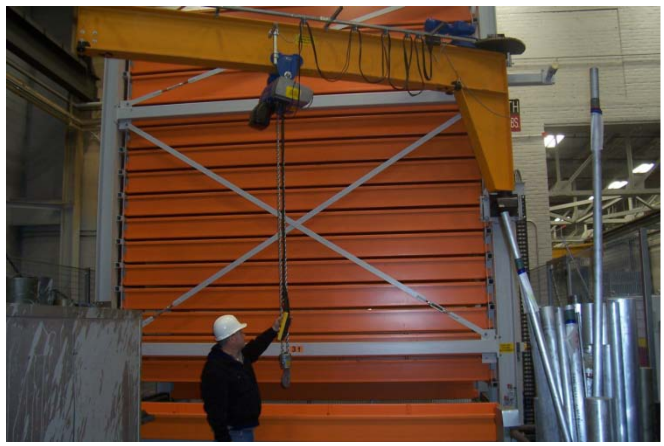

Figure 20: Vertical index unit for round stock has a security access codes for level one stock and incorporates a jib crane at New London CT

Reduce lifting and carrying forces
Improve raw material quality
Enhance inventory control
Boost security

Hose Reels	
Description: Devices that provide a mechanical advantage in supporting or cables or long hoses. **Advantage:** • Reduces force needed to roll hoses • Hose reels can be customized for special needs **Points to Remember:** • Minimize tangles and pinch points in the travel path to reduce the pulling forces	 Figure 21: Welding lead on a pulley help to reduce awkward postures Reduce lifting and pulling forces

Handling Equipment / Manipulators / Handles

Grippers and Handles	
Description: Overhead handling equipment from engine hoists to boom cranes can be used to move heavy equipment to reduce the frequency of heavy lifting. **Advantage:** • Eliminates heavy lifting and carrying. • Allows heavy or awkward materials, tools or equipment to be moved without carrying. • Saves time and effort **Points to Remember:** • Different handling system and grippers are available for many situations.	 Figure 23: Southeast Regional Maintenance Center- portable gantry is used for raw material, moving dies, and finished products

Figure 22: Suction manipulator used to move sheet metal

Figure 24: Grabbing clamp used at Naval Aviation Depot Jacksonville FL

Reduce pushing, pulling, lifting and carrying forces

Overhead Handling Equipment

Description: Overhead handling equipment for lifting and moving large pieces.

Advantage:

- Eliminates heavy lifting and carrying.
- Allows heavy or awkward materials to be moved, stored and loaded for distribution without carrying.
- Saves time and effort.

Points to Remember:

- Different handling system and grippers are available for many situations.
- Ensure system / device is rated for the load weight.

Figure 25 Manual lifting and carrying of fabricated work piece (US Naval Observatory)

Figure 26 Overhead crane eliminates hazards, saves time and effort and protects finished product

Reduce lifting, pushing and pulling forces

Handling Equipment

Description: Vacuum handling devices and magnets can be used to reduce heavy lifting or provide better handling points.

Advantage:
- Eliminates compressive forces on the hands.
- Grips can be attached to overhead equipment or fork trucks
- Ensure a safe grasp point that is free from burrs.

Points to Remember:
- Different grippers are available for many situations.

Figure 27: Magnetic and Vacuum handles

Figure 28: Grabbing clamp used at Naval Aviation Depot Jacksonville FL

Figure 29: Vacuum lifter attached to fork truck to move materials

Diminish compressive forces on the hands
Reduce lifting, pushing and pulling forces

Handling Equipment

Description: A welding unit with an attached fixture or handle.

Advantages:

- Allows welding unit to be moved upstairs, safely, with two people
- Allows two-people to share the load
- Reduces muscle fatigue and the risk of back injury

Points to Remember:

- A small wheeled dolly can be used to transport welding equipment without lifting
- Welding handle design available from the Navy Ergonomics Subject Matter Experts (see resources).

Figure 30: Before: One welder struggles to carry power con up stairs

Figure 31: After: The supervisor fabricated a handle that allows to people to share the load and have three points of contact on the stairs used at Southwest Regional Maintenance Center San Diego

Reduce carrying forces

Positioning Equipment

Material Positioning Equipment

Description: An anvil or positioning device is useful to hold smaller components during welding or material at an appropriate level.

Advantage:

- The anvil can be positioned to reduce awkward postures of the neck, back, hands and wrists by positioning the work piece instead of the worker.
  Work surfaces that are easy to raise or lower allow employees to work in neutral postures

Points to Remember:

- An adjustable work table, work chair or standing platforms may be necessary to accommodate different size work pieces.
- Surfaces must be able to support the weight of the object or material.
- Welding tables come in a variety of sizes with fixtures for small or large parts and can be joined together for larger work pieces

Figure 32 Welding tables can be joined together for larger parts and include clamping options to accommodate many sizes

Figure 33 Rotating manipulator allows pieces to be held and manipulation in every direction.
Mobile

Reduce awkward body postures

Material Positioning Equipment – Simple Solutions

Description: In the before photos you can see the workers are in a very awkward posture. Simply elevating the work piece significantly reduces the stresses on the worker's back.

Advantage:

- Reduced awkward neck and back posture
- Safer
- Low cost

Points to Remember:

- Solutions do not need to be costly to be effective.


Figure 34 Before: Welder is bent over work piece


Figure 35: After: Low cost work table greatly improves posture


Figure 36 Before: Welder's neck and back are in an awkward posture while he kneels on a hard surface


Figure 37 After: Simple trailer jack lifts work piece and improves posture at Fleet Readiness Center East

Reduce awkward body positions
Decrease contact stress on the lower body from kneeling on hard, cold surfaces

Custom Fabricated Work Piece Positioning Equipment

Description: Product specific positioning devices are useful to hold components during welding or place material at an appropriate level.

Project Summary and Advantages:

- A height adjustable, rotating mobile fixture for transporting and repairing propellers. The fixture promotes neutral postures during repair work by allowing the employee to work in a standing position with the propeller angled toward them thus reducing exposure to ergonomic stressors.
- The propellers can be transferred from the hovercraft directly to the fixtures and remain on the fixtures during the entire repair process in order to eliminate unnecessary manual material handling.
- Use of the fixtures reduces possible damage to the propellers during handling, improve productivity, and decrease ergonomic stressors associated with the repair operation.

Points to Remember:

- Fixtures do not need to be costly to be affective in promoting neutral body postures.

Figure 39: Awkward postures during propeller repair

Figure 40: Fixture is height and angle adjustable

Figure 38: Accommodation ladders shop - workers designed a fixture to support and rotate accommodation ladders during welding and repair operations, MPHA program working with the accommodation ladder and watertight fitting shop to improve concept design and functionally through engineering.

Figure 41: Propeller fixture

Reduce awkward posture and muscle loading

People Positioning Equipment

Description: Angle adjustable creeper.

Advantages:
- Height and or angle adjustable creepers and tool stools allow the welders to get closer to their work while supporting some of the body weight.

Points to Remember:
- Ensure materials used for these devices are flame resistant or retardant.
- Maintain casters for ease of movement.

Solution Source:
- Fleet Readiness Center East

Figure 42: Before: Welder is in awkward posture to reach beneath work piece

Figure 43: After: Welder is in a supported poster and can easily see the work piece

Reduce awkward posture and muscle loading

People Positioning Equipment

Description: Positions and supports welder.

Advantages:

- Height and or angle adjustable creepers allow the welders to get closer to their work while supporting some of the body weight.
- Lean forward type welding stool relieves some static back loading.

Points to Remember

- Ensure materials used for these devices are flame resistant or retardant.

Figure 44: Height adjustable chair

Figure 45: Welding stool supports torso and relieves some static muscle loading

Reduce static loading and awkward posture

Equipment

Welding Helmet with Auto-darkening Lens	
Description: Lens automatically darkens when spark ignites. **Advantages:** • Greatly reduces repetitive forward neck impact to close traditional helmet • Lenses are interchangeable • Models incorporate sensitivity or delay control **Points to Remember** • Insure shade, delay, and sensitivity features match working environment and welding type.	 Figure 46: Auto darkening welding lens Reduce impact force

Robotic Welders

Description: Remote operation welding.

Advantages:

- Reduced fatigue associated with welding in awkward or constrained postures
- More efficiency
- Greater consistency of quality welds
- Increased repeatability
- Reduced production costs

Points to Remember:

- Not applicable for all welding applications

Figure 47: Robotic welder

Reduce awkward postures
Diminish repetitive motions

Electromagnetic and Air Presses

Description: Portable electromagnetic and air presses hold parts in place during welding.

Advantages:

- Reduces awkward postures and forceful exertions associated with manually clamping parts prior to weld operations
- Can reduce job completion time

Points to Remember

- Useful for long seams

Figure 48: Welder using manual clamp method


Figure 49: Air press clamp


Figure 50: Welder using air press clamp system

Reduce forceful exertions

Training and Action Plan

Training
A key element in implementing solutions for ergonomics stressors is training. Per OPNAVINST 5100.23(series), Chapter 23 Ergonomics Program, paragraph 2308.a, "A key to maintaining an effective ergonomics program is the proper training of managers, supervisors, professional staff, ergonomic teams and employees. General ergonomics training shall be provided to all employees as applicable to the employee's role in the workplace."

General ergonomics training can be taken on line at:

Navy eLearning https://www.nko.navy.mil/ (search ergo for listing) or, through the Enterprise Safety Application Management System (ESAMS).

A PowerPoint version of the training can be downloaded from the Ergonomics page training tab at: http://www.navfac.navy.mil/safety

Action Plan for Implementing Solutions to Reduce Workplace Risk Factors

- Step 1: Look for clues
    - Observe work activities
        - Risk factors
        - Worker fatigue
        - Tool / equipment modifications
        - Increased absenteeism
        - Decreased production
        - Bottlenecks / missed deadlines
    - Talk to workers (form ergonomics action teams or designate an ergonomic point of contact)
    - Use assessment tools
        - Risk factor physical check list (OPNAVINST 5100.23(Series), Rapid Upper Limb Assessment (RULA)
        - Rapid Entire Body Assessment (REBA)

- Step 2: Prioritize job for improvements
    - Consider
        - Frequency & severity of the risk factors
        - Frequency & severity of complaints
        - Injuries
        - Workers' ideas
        - Timeframe for making improvements
        - Difficulty in making improvements

- Step 3: Make improvements
    - Improve the fit between task demands & worker capabilities

  - Talk to various employees (see following up section)
  - Contact other industries
  - Consult ergonomics experts
  - Use internet resources (see references and resources section)

- Step 4: Follow-up:
  - Has each improvement reduced or eliminated the risk factors, fatigue, discomfort symptoms or injury reporting?
  - Has each improvement been accepted by the workers?
  - Have any improvements created new risks or other problems?
  - Have any improvements impacted production or quality?
  - Are implemented improvements supported by training?

References

1. OSHA Guidelines for Shipyards; OSHA 3341-03N (2008) Ergonomics for the prevention of Musculoskeletal Disorders http://www.osha.gov/dsg/guidance/shipyard-guidelines.html

2. National Institute for Occupational Safety and Health: Publication number 2007-131: Ergonomics Guidelines for Manual Material Handling http://www.cdc.gov/niosh/docs/2007-131/.

Resources

- Naval Facilities Engineering Command Ergonomics Subject Matter Expert site http://www.navfac.navy.mil/safety (Select Ergonomics) Visit the web site for more information and your eligibility for no cost ergonomics technical support.

- For more information on the Mishap Prevention and Hazards Abatement Program funding and submittal process , visit Naval Facilities Engineering Command www.navfac.navy.mil/safety (Select Hazard Abatement)

- Easy Ergonomics: A practical approach for improving the work place: Occupational Safety and Health Administration & California OSHA Services. www.cbs.state.or.us/osha/pdf/pubs/3347.pdf

- Washington State Department of Labor and Industries Safety webpage at: www.lni.wa.gov/Safety/Topics/Ergonomics
    - A database of ideas to reduce ergonomics risk factor exposures found at the Washington State Department of Labor and Industries Safely – Ergonomics webpage Ergonomics Ideas Bank link

- Naval Safety Center Success Stories http://www.safetycenter.navy.mil/ (Select Success Stories under References) Navy Safety and Occupation Heath (SOH) Program Manual (OPNAVINST 5100.23G), http://www.safetycenter.navy.mil/ (Select Instructions under References and go to OPNAV)
  Chapter 23 Ergonomics Program
  Chapter 12 Hazard Abatement

- Department of Defense Instruction Safety and Occupation Health Program (DoDI) 6055.1, Enclosure (6) DoD Ergonomic Program Requirements and Procedures, http://www.dtic.mil/whs/directives/corres/pdf/605501p.pdf

Acknowledgements

For questions/comments contact:

Navy Ergonomics Subject Matter Expert
1220 Pacific Highway
San Diego, CA 92132-5190
Phone: Commercial (619)532-2536, DSN 522-2536
www.navfac.navy.mil/safety (select ergonomics)

Prepared by:
Navy Ergonomics Working Group.