Naval Facilities Engineering Command

Ergonomics Risk Assessment for

Introduction

This report summarizes the ergonomics risk assessment conducted on June 21st and 22nd 2005. The Pump, Antenna, Engine, and Welding Shops were observed in order to determine sources of ergonomics stress and recommend improvements. This assessment is based upon interviews with employees, supervisors, and safety personnel as well as an evaluation by the Naval Facilities Engineering Command (NAVFACENGCOM) Hazard Abatement and Mishap Prevention (HAMP) occupational ergonomist.

The risk assessment was conducted in conjunction with the Job Requirements and Physical Demands Survey (JR/PD). The JR/PD is an ergonomics survey designed to assess ergonomics risk in the workplace. Appendixes I through IV contain the specific survey results for each job area as well as the survey methodology. Priority scores are based upon a combination of physical risk factors associated with the job and employee reported discomfort. An Overall Job Priority score of five or greater establishes a task/job as an ergonomic problem area (EPRA) on a scale from one to nine, where nine is the highest priority for intervention. The pump, antenna, and welding shops were ergonomics problem areas. The Overall Job Priority score is determined by selecting the highest body region score for the job.

> The Pump Shop had an overall priority score of **5**. The shoulder/neck, hand/wrist/arm, back/torso and leg/foot regions all had significant scores (greater than 4).
>
> The Antenna Shop had an overall priority score of **7**. The back/torso region had a significant score.
>
> The Welding Shop had an overall priority score of **9**. The shoulder/neck, hand/wrist/arm, and back/torso regions had significant scores.
>
> The results from the Engine Shop were not significant.

The operations reviewed present opportunities to reduce the risk of work-related musculoskeletal disorders (WMSDs). Recommendations to the command to reduce the probability of injury include equipment purchase[1], process redesign, and implementation of administrative controls[2].

Musculoskeletal Disorders (MSDs) are injuries and illnesses that affect muscles, nerves, tendons, ligaments, joints, spinal discs, skin, subcutaneous tissues, blood vessels, and bones. Work-Related Musculoskeletal Disorders (WMSDs) are:

> Musculoskeletal disorders to which the work environment and the performance of work contribute significantly or

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Musculoskeletal disorders that are aggravated or prolonged by work conditions.

Representative vendor information is included in the recommendations to assist in the evaluation of products and services[3]. Recommendations to the command include gathering input from the workers, safety specialists, and other personnel to evaluate equipment before purchasing. This process will increase product acceptance, test product usability, and durability, and takes advantage of employee experience.

Naval Facilities Engineering Command (NAVFACENGCOM) manages the Chief of Naval Operations (CNO) Hazard Abatement and Mishap Prevention Program, which is a centrally managed fund to correct safety and health deficiencies beyond the funding capabilities of the activity. The activity has already applied for funding for each of these shops in the following projects:

222CT Small engine/diesel shop - $90,000

225CT Pump shop- $32,000

226CT Welding shop- $23,700

238CT Antenna Shop- $80,000

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Pump Shop

Purpose of the Operation: Repair and overhaul pumps.

Population: 27 active duty personnel and 1 civilian shop-master work one shift

Injury Data: None available

Description of the Operation: Employees go to the ship and disconnect the flanges in order to remove the pumps. Heavy pumps are lifted by riggers using a crane and loaded onto a truck or cart. When pumps arrive in the shop they are removed with a forklift or by hand onto a cart and brought inside, figure 1. Pumps are then washed if necessary and disassembled. If the part requires painting or sandblasting it stays on the cart. After sandblasting and painting, the cart is cleaned with water or air, taken to the oven, coated, and then re-assembled. If the pump doesn't require painting or sandblasting it is moved onto a table for work, photo 2.

Workers stand at the table performing repairs for up to 5 hours at a time. The amount of time spent repairing pumps depends on the extent of the problem being addressed. The shop repairs about 8-10 pumps a week. Each pump is handled 5 or 6 times during the repair process.

Figure 1: 300+ lb pump on a cart

Figure 2: Working on a pump on a table

JR/PD Summary (Refer to Appendix I): The JR/PD survey results indicate that the pump shop is an ergonomics problem area with an overall priority score of **5** on a scale from 1 to 9, where nine has the highest priority for intervention. A score of 5 or higher is considered significant. Thirty-six percent of the respondents have seen a health care provider in the past twelve months for pain or discomfort that he or she feels is related to the job. A significant number of employees reported pain and discomfort that does not abate when away from their job. A significant number of employees also report pre-existing MSDs, and other contributing factors which places them at increased risk of developing additional or more severe MSDs. The shoulder/neck, hand/wrist/arm, back/torso, and leg/foot regions all had significant scores. The results are contained in Table 1.

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Table 1		Body Regions				
		Shoulder/ Neck	Hand/Wrist/Arm	Back/ Torso	Leg/ Foot	Head/ Eye
Priority Score		5	5	5	5	1
Risk	Prevalence	50%	46%	46%	46%	18%
	Rating	Medium	Medium	Medium	Medium	Low
Discomfort	Prevalence	32%	32%	43%	36%	14%
	Rating	Medium	Medium	Medium	Medium	Low

Ergonomics Issue Description: The major ergonomics risk factors for the pump shop are awkward posture and forceful exertions, which may have contributed to the significant JR/PD results for the shoulder/neck, hand/wrist/arm, back/torso and leg/foot regions. Workers sustain awkward postures and prolonged standing while performing repair operations. Moving pumps through the different operations requires repeated heavy lifting. The chance of developing WMSDs is increased when risk factors (e.g. posture and force) occur in combination, especially for significant frequency and duration which increases exposure.

Awkward Postures: Workers assume awkward postures while performing repair tasks due to fixed height tables, photo 2. Working at surfaces that are too high or too low for the height of the worker can affect several parts of the body. Employees lift and/or bend their shoulders, elbows, and arms (including hands and wrists) into uncomfortable positions to perform the tasks. In addition, workers have to bend their heads and necks to see their work, photo 1. The muscles must apply considerably more contraction force to maintain awkward postures. As the duration of the contraction increases, stress on the muscles also rise. The continuous stress on these muscles can lead to fatigue and discomfort which can be precursors to injury.

Excessive Lifting: The workers risk injury from forceful exertions caused by lifting the pumps onto and off the work carts and tables. Forceful exertions can place high loads on the muscles, tendons, ligaments, and joints being used. Increasing the force required to lift a load also means increasing body demands (i.e. greater muscle exertion is necessary to sustain the increased effort) and imposing greater compressive forces on the spine. As force increases, muscles fatigue more quickly. Prolonged or frequent exertions of this type can lead to WMSDs when there is not adequate time for rest or recovery. A lack of carts increases the need to move pumps by hand when the cart in use is needed elsewhere.

The Department of Defense Design Criteria Standard for Human Engineering (MIL-STD-1472F) addresses lifting objects. According to MIL-STD1472F, one male worker can safely lift an object up to 87 pounds from the floor and place it on a surface not greater than 36" from the floor. This recommended weight is reduced to 44 pounds for a female worker. Two male workers can lift 174 pounds under the same circumstances.

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The recommended weight limit is reduced to 88 pounds if one or both of the workers are female. The recommended weight limit is routinely exceeded for pumps weighing up to 300 pounds. Exceeding the recommended weight limit places the workers at increased risk of back injury.

Prolonged Standing: Workers stand for most of the day on concrete. Standing for long periods of time can be a strenuous activity that promotes blood pooling in the legs and feet and has been know to produce discomfort and fatigue. Prolonged standing may have contributed to the leg/foot discomfort in the JR/PD results.

Recommendations:

- Portable scissors lift tables will help reduce frequent lifting of the pumps from the carts to the worktables; thereby, greatly reducing the risk of injury. The portable scissors lift tables can also be used as adjustable work surfaces once the cart tops are properly protected. The adjustable surface will allow the workers to position the pump to match the repair task and stature of the worker, reducing the need to maintain awkward postures. Additionally, the new equipment should increase productivity by reducing the number of times two workers are required to lift the pumps. A stainless steel lift cart can be used in the painting and sandblast area. Refer to vendor table 1 for more information.

- Anti-fatigue matting or sole inserts for standing work areas can reduce fatigue. If the worker remains in a confined area, anti-fatigue matting is a durable and efficient way to reduce fatigue. If the operator regularly leaves their workstation or spends much of their time walking, sole inserts may be a better option. Refer to vendor table 1 for more information.

Vendor Table 1 – Pump Shop

Product	Vendor	Estimated Cost	Figure
Anti-Fatigue Matting Beveled edges are recommended for areas with cart use.	Lab Safety 1-800-356-0783	Price varies by size.	
	Matting World 1-800-254-8557		
	Safeworker* recommended by NADEP Jax 1-888-456-3372	18" X 36 " Extreme Standing Mat with Beveled strips $43.46 3'X5' Extreme standing mat with bevel strips $156	

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Vendor Table 1 – Pump Shop			
Product	Vendor	Estimated Cost	Figure
Inner-soles	Guard Industries *Recommended by NADEP Jax 1-314-534-6952	Body Cushion #3059 Hiker/casual insoles $5.21	
Scissors Lift Table Price depends on weight capacity, construction material and table top size.	Grainger	$401-$1831	
	C&H 1-800-558-9966	$386-$1629	

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Antenna Shop

Purpose of the operation: Repair and refurbish ship antenna

Population: 5 Active duty personnel

Injury Data: No recorded injuries

Description of the Operation: Employees remove antenna from the ships and load them onto a trailer, figure 3. Removing bolts in order to retrieve the antenna requires the workers to assume awkward postures. The largest antenna is 35 ft. long and is comprised of two pieces; a 175 pound base and a 40 pound tip. Two or three workers handle the antenna and disassemble them on the trailer. If the antenna is intricate (with a lot of surfaces or detail) or heavily damaged it is taken directly for sandblasting. About half of the incoming antennas require sandblasting, figure 4. Otherwise, the antennas are taken from the trailer to a tent for sanding, paint preparation, and cleaning.

Antennas are lifted onto a set of sawhorses for sanding, figure 5. Each worker usually spends about 2 hours sanding each antenna. A worker can sand up to 3 antennas a day which amounts to a possible 6 hours of sanding per day. Time spent sanding depends on the size of the antenna and amount of build-up. After the antenna has been sanded, it is taken from the tent or the sandblaster to the paint booth. The tent, painting and sandblasting areas are on opposite sides of the facility. The antenna can be moved part of the way by trailer but are then hand carried, figure 6. On average, about 6 antennas are completed each day. Each antenna is moved about 5 times during the repair process.

Figure 3: Trailer for transporting antenna

Figure 4: Simulated sandblasting

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Figure 4: Sawhorses for sanding

Figure 5: Lifting Antenna

Each antenna receives 3 coats of paint in the paint booth, 1 primer coat and 2 top coats. It takes about 2 hours to paint each coat and 8 hours of curing or drying time between coats. The workers use a cart, figure 6, which supports 4 antennas at a time for painting. The base of the antenna bolts onto the cart (in the upper position) and the tip slides on the protruding bar in the lower position. The top antenna can be rotated during painting to prevent drips. The base of the antenna can not be rotated since it is bolted in the place, so the worker has to bend to access all sides for painting. Smaller antennas are hung on cables.

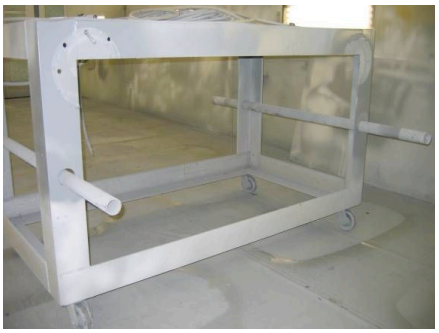

Figure 6: Antenna Cart for painting

The Antenna Shop also repairs fan wire antennas. A fan wire antenna is comprised of wires and connectors forming a pie-shaped web of wire antennas. The unit is about 70 ft. long and 15-20 feet wide. In good weather the system can be spread on the ground for repair work. If the system can't be spread out, it tends to tangle. Up to four employees will work on a web antenna at a time. Every ship has a fan wire antenna and the shop services about 15 ships per year.

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Figure 7: Fan wire antenna in a pile on the floor

JR/PD Summary (Refer to Appendix II): The JR/PD survey results indicate that the antenna shop is an ergonomics problem area with an overall priority score of **7** on a scale from 1 to 9, where nine has the highest priority for intervention. A score of 5 or higher is considered significant. In addition, a significant number of employees reported pain and discomfort that does not abate away from their job and has interfered with carrying out normal activities. The back/torso region has a significant score. The results are contained in Table 2.

Table 2		Body Regions				
		Shoulder/ Neck	Hand/Wrist/Arm	Back/ Torso	Leg/ Foot	Head/ Eye
Priority Score		4	1	7	4	2
Risk	Prevalence	67%	0%	67%	67%	33%
	Rating	High	Low	High	High	Medium
Discomfort	Prevalence	0%	0%	33%	0%	0%
	Rating	Low	Low	Medium	Low	Low

Ergonomics issue description:
The major ergonomics risk factors for the antenna shop are excessive lifting, awkward postures and vibration exposure. Due to the magnitude and frequency of the exposure, the combination of these risk factors may contribute to the development of WMSDs.

Static Awkward Postures: The sanding and painting tasks constitute the majority of the work performed by the crew. The fixed position of the sanding / painting jigs forces the workers to maintain static awkward postures for extended periods. The worker positions his or her body to accommodate the antenna while using powered hand tools and paint-sprayers. Awkward postures are of a particular concern for workers who perform repetitive jobs such as sanding due to the cumulative effects of exposure. Awkward postures, which include kneeling on hard surfaces or bending to paint the underside of the antennas can lead to fatigue and discomfort.

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Static postures can result in increased loads or forces being exerted on the muscles and tendons used to accomplish antenna repair, which may contribute to fatigue. This occurs because static awkward postures impede the flow of blood needed by the muscles to bring nutrients and to carry away the waste products of muscle metabolism. Reduced blood flow also slows delivery of oxygen to the muscles resulting in a longer recovery time. Awkward postures increase the muscular effort required to do the task. The longer or more frequently static loading occurs, the greater the risk of injury due to overuse of muscles, joints, and other tissues. The effects of static loading are magnified when combined with vibration exposure from hand tools such as sanders.

Excessive Force: Antennas are moved up to five times during the repair operation and are frequently carried through the facility. Lifting and carrying heavy antennas places the workers at risk of back injury and may have contributed to the significant JR/PD survey results for the back/torso region.

The Department of Defense Design Criteria Standard for Human Engineering (MIL-STD-1472F) addresses carrying objects. According to the MIL-STD, the weight one person can carry (up to 33 ft) without an increased risk of injury is a maximum of 42 pounds. The maximum weight two people can carry is 82 pounds (if the load is evenly distributed). The fully assembled antenna exceeds these maximum weight limits for carrying while the antenna sections may, depending on the particular antenna.

Vibration: The sanding task requires the use of hand tools which expose the worker to vibration. The National Institute of Occupational Safety and Health conducted a critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. The review found strong evidence of a positive association between high level exposure to hand-arm vibration and vascular symptoms of hand-arm vibration syndrome (HAVS). For example, vibration can result from bad design, poor maintenance, and age of the powered hand tool. New powered hand tools even expose employees to excessive vibration if they do not include devices to dampen the vibration or shield the operator from it. There is substantial scientific evidence that as intensity and duration of exposure to vibrating tools increases so does the risk of developing HAVS.

Recommendations:

- An antenna cart will reduce heavy lifting and promote neutral postures. Antennas can then be transported through the facility on a cart rather than by hand. The cart will be made of light weight aluminum, with a 12 V hydraulic lifting system, antenna restraining straps and a plug-in 100 Volt battery charger, figure 8. Anteon Corporation has quoted $13,200 for this project.

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Figure 8: Antenna cart

- A specially designed fixture to lift the fan wire antenna will allow the employees to work on the unit in a standing position and let it rise up as completed.
- Retrofitting the current cart in the paint booth with an enclosed set of bearings which will allow the base antenna to be rotated during the painting process. Rotating the antenna will promote neutral working postures and improve product quality.
- Four tool stools with large casters will allow the employees to work at floor level without kneeling or bending. Refer to vendor table 2.
- Knee pads or wedges can also help reduce fatigue for workers kneeling to work on web antennas. Refer to vendor table 2.
- Low vibration tooling will help reduce vibration exposure for the workers. Refer to vendor table 2. The vibration level of the tool should conform to the (ACGIH) 2005 Threshold Limit Values (TLVs) found in Table 3. The indices represent conditions under which it is believed that nearly all workers may be exposed repeatedly without progression of various Hand Arm Vibration Syndrome (HAVS) Exposure to vibration above the levels listed in the table constitutes overexposure, which magnifies the risk of HAVS. New tools can be purchased in conjunction with a local exhaust dust capture system to greatly reduce the risk of inhalation exposures. In addition, the National Institute of Occupational Safety and Heath vibration guideline offers further guidance on engineering controls, tool maintenance, work-rest cycles, personal behaviors, and vibration dampening gloves.

Table 3: TLVs for Exposure of Hand Vibration*	
Total Daily Exposure Duration	Values of the Dominant, Frequency-Weighted, rms, Component Acceleration which shall not be exceeded (m/s^2)
4 hours and less than 8	4
2 hours and less than 4	6

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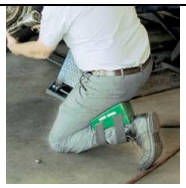
1 hour and less than 2	8
Less than 1 hour	12

**Source: 2005 Threshold Limit Values and Biological Indices, American Conference of Governmental Industrial Hygienists.*

Vendor Table 2 – Pump Shop			
Product	Vendor	Estimated Cost	Figure
Tool Stools	Lab Safety 1-800-356-0783	$199	
	C&H 1-800-558-9966	$156	
	Grainger	$203	
	Alimed 1-800-225-2610	$19-$40	
Knee pads	Lab Safety 1-800-356-0783	$16	
	Grainger	$10-$36	
	Alimed 1-800-225-2610	Industrial Knee Saver	
Low vibration tools	Atlas Copco 800 654 5965	Price depends on tool	

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Vendor Table 2 – Pump Shop			
Product	Vendor	Estimated Cost	Figure
	Dynabrade 716 631 0110		
Vacuum Systems	Desco 800 337 2648	$1500	
	DCM 800 624 4518		

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Engine Shop

Purpose of the Operation: Repair and rebuild boat engines.

Population: 17 active duty personnel

Process Description: The engine shop identifies and repairs problems with boat engines. Upon receipt of the engines, workers assess the damage and extent of repairs required. The engine is then disassembled, repaired, re-assembled and sent back to the vessel.

The engine shop completes about 4 to 5 frigate engine overhauls per year, each taking about a month and a half, figure 9. A 149 Detroit frigate diesel engine weighs about 2,000 pounds without components. The engine has to be flipped approximately 4 times during the repair process to access components. The workers currently use a manual chain fall hoist from an overhead lift to handle the engine.

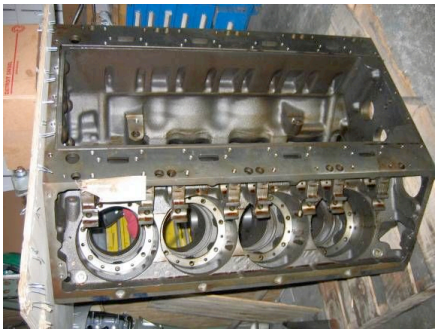

Figure 9: Diesel frigate engine

The engine shop also repairs Auxiliary Power Units (APUs) which weigh about 6,000 pounds. The loading area is lower than the shop floor and the entryway is not tall enough for the forklift to enter so four sailors are required to manhandle the APUs into the shop. The forklift is used to transfer the APU to a work stand which is then pulled across the threshold over the raised door sill by four sailors. There have already been two incidents of APUs being dropped which poses a significant safety/crushing hazard. The engine shop has 4 work stands which were made in-house, figure 9. The shop repairs one APU at a time. Each APU takes two days to repair: one day to break down and one day to rebuild. The APUs are disassembled with mallets requiring heavy force exertions as shown in figure 9.

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Figure 9: Disassembly of an APU

Repairs of smaller engines, known as P100s, are performed on work tables. Each P100 weighs about 150 lbs. and is lifted by two workers, figure 10. The table is too large to reach the engine from both sides so the engine has to be rotated by hand to access each side. The engine shop repairs about five P100s each month. A single engine can take up to 10 days depending on the extent of the repairs required.

Figure 10: Workers lifting a P100

The engine shop also repairs small outboard motors. The outboard motors are stored on rolling stands, figure 11. Currently the workers perform maintenance operations with the motors on the stands, but the stands were not designed for this task and are breaking which creates a safety hazard.

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Figure 11: Outboard motor stand

JR/PD Summary: The JR/PD survey results indicate that the engine shop is not an ergonomics problem area although significant ergonomics risk factors were found with this task. Employees with diverse responsibilities who are exposed to different types of risk factors can lower a JR/PD score. Under-reporting of discomfort, which is common in an active duty population, or risk factors can also lower a score. The employee's process improvement ideas are contained in Appendix IV.

Ergonomics Issue Description: The ergonomics risk factors associated with the engine shop are excessive force and awkward postures associated with the repair process.

Excessive Force: Moving engines around the shop and during repair tasks requires frequent heavy lifting. The APU requires four workers to move across the door sill into the shop. According to MIL-STD 1472F, four male workers should not exert more than 750 Newtons or 168.75 pounds of horizontal force intermittently or for short periods on a medium traction surface. Pushing a 6,000 pounds APU exceeds the recommendations of the standard and places the workers at risk of cumulative and traumatic injuries.

Disassembling the APUs also requires forceful exertions. Strong force exertions can contract the muscles beyond their maximum capability which can lead to fatigue and possible damage to the muscles and other tissues. Frequent heavy lifting, particularly in awkward postures can increase compressive forces in the spine which increases the risk of injury.

Awkward Body Postures: Since many of the engines are repaired on stands or workbenches in a fixed position, the worker has to bend and twist to access components. Workers maintain static awkward postures for extended periods while performing assessments and repairs. While using hand tools, the worker is required to hold arms in an extended position in order to reach the engine and/or to bend the back and neck to properly view the engine.

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Recommendations:

- A new height and angle adjustable APU stand will promote neutral postures and improve maneuverability while reducing heavy force exertions. This item will have to be specially designed and constructed.
- A pallet mule/tug will help the workers transport items through the shop without the workers having to exert heavy forces. Refer to vendor table 3.
- A pneumatic hoist will also reduce the force required to move engines through the shop and during the repair process. Refer to vendor table 3.
- Scissor lift carts for the P100s will allow the employees to repair the engines while they are on the carts; thereby reducing heavy lifting and awkward postures. The workers can walk around the cart rather than rotate the engine. Refer to vendor table 1.
- Three tool stools with large casters will allow the employees to work at floor level without kneeling or bending. Refer to vendor table 2.
- Six mobile stands are recommended to assist with the movement and repair of outboard motors. Refer to vendor table 3.

Vendor Table 3 – Engine Repair

Product	Vendor	Estimated Cost	Figure
Pallet Mover	Global Industrial 1-800-645-1232 Self-propelled pallet truck (battery powered, 4,500 lb. capacity)	$3900	 Also available Self-propelled manual lift 3000 lb. Capacity truck
	C&H 1-800-336-1331 Fully Powered Pallet Truck (Multiton or Big Joe)800-336-1331	$2267	

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Vendor Table 3 – Engine Repair			
Product	Vendor	Estimated Cost	Figure
	Lab Safety and Supply 1-800-356-0783 Light/Medium Duty Multiton Powered Pallet Truck	$2267-$3750	
Pneumatic Hoist	Grainger 2 Ton capacity	$5,000	
Low vibration tools	C.G.Edwards & Co.Inc. (617)268-4111	$215	
	Marine Products 1-800-973-2834	$189	

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Welding Shop

Purpose of the operation: Perform ship repairs requiring welding

Population: 20 Active duty personnel

Injury Data: No recorded injuries

Description of the Operation: Welding is the most common way of permanently joining metal parts. In this process, heat is applied to metal pieces, melting and fusing them to form a permanent bond. The welding shop performs welding operations in the shop and onboard ship during repairs.

Metal is usually placed on a fixed height table or on the floor for welding operations performed in the shop. The table in the welding area is 54.5" tall. Welding requires frequent heavy lifting and carrying. Welding operations require the use of bottles of compressed gas which can weigh 125 pounds when empty, figure 12. Full gas bottles can require up to 4 workers to lift and carry. Smaller gas bottles are carried on the worker's shoulder. Grisley power-cons weigh between 125 and 140 pounds and pipes weigh up to 150 pounds.

Figure 12: Bottles of compressed gas

JR/PD Summary (Refer to Appendix III): The JR/PD survey results indicate that the welding shop is an ergonomic problem area with an overall priority score of **9** on a scale from 1 to 9, where nine has the highest priority for intervention. A score of 5 or higher is considered significant. Thirty eight percent of the survey respondents reported having seen a health care provider for pain or discomfort related to the job. A significant number of employees reported pain and discomfort that does not abate away from their job. A significant number of employees also report pre-existing MSDs, and other contributing factors which places them at increased risk of developing additional or more severe MSDs. The shoulder/neck, hand/wrist/arm, and back/torso regions had significant scores. The results are contained in Table 3.

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Table 3		Body Regions				
		Shoulder/ Neck	Hand/Wrist/Arm	Back/ Torso	Leg/ Foot	Head/ Eye
Priority Score		7	8	9	4	1
Risk	Prevalence	75%	50%	63%	75%	25%
	Rating	High	Medium	High	High	Low
Discomfort	Prevalence	50%	63%	63%	25%	25%
	Rating	Medium	High	High	Low	Low

Ergonomics Issue Description: Welders are exposed to a number of hazards, including the intense light created during welding, poisonous fumes, and very hot materials. The major ergonomics risk factors associated with the welding are awkward posture and heavy lifting. Workers sustain awkward postures while performing repair operations. Moving parts for welding requires heavy lifting. The chances of developing WMSDs are increased when risk factors (e.g. posture and force) occur in combination, especially for significant frequency and duration.

Sustained Awkward Postures: Workers assume sustained awkward postures during welding operations. Welding on the floor causes workers to squat or kneel which places biomechanical stress on the knees which can lead to fatigue and discomfort, figure 13. Hyper-flexing the knees in a squatting or kneeling position can result in pressure on the back of the knees which may reduce circulation in the lower extremities.

Workers perform shop welding on fixed height work surfaces. When the work item can not be brought up to the worker, the worker has to adjust his or her body to view and reach the work. Ergonomics related stressors associated with welding include neck inclinations, bent back postures, non-neutral arm positions, wrist deviations, and contact stress to the lower extremities, figure 14. Working onboard ship also forces employees to maintain awkward postures in order to perform repairs in constrained spaces. The muscles must apply considerably more contraction force to maintain awkward postures. As the duration of the contraction increases, stress on the muscles also rise. The continuous stress on these muscles can lead to fatigue and discomfort which can be precursors to injury. Static awkward postures impede the flow of blood needed by the muscles to supply nutrients and carry away the waste products of muscle metabolism. Reduced blood flow also slows delivery of oxygen to the muscles resulting in a longer recovery time. Awkward postures increase the muscular effort required to do the task. The longer or more frequently static loading occurs, the greater the risk of injury due to overuse of muscles, joints, and other tissues.

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Figures 13 and 14: awkward postures during welding
(Photos from MCLB Barstow)

Workers who use traditional welding hoods have a tendency to lower the shield with a jerking motion of the neck to snap it shut. Frequent, abrupt neck motions can put stress on the neck and spine.

Excessive Lifting: The workers risk injury from forceful exertions caused by handling items for repair and moving materials such as pipes and gas cylinders. Forceful exertions can place high loads on the muscles, tendons, ligaments, and joints being used. Increasing the force required to lift a load also means increasing body demands (i.e. greater muscle exertion is necessary to sustain the increased effort) and imposing greater compressive forces on the spine. As force increases, muscles fatigue more quickly. Prolonged or frequent exertions of this type can lead to WMSDs when there is not adequate time for rest or recovery.

Recommendations:

- Portable scissors lift tables will help reduce frequent heavy lifting. The tables can be lowered to pick up materials and then raised to the height of the work surface for transfer. Refer to vendor table 1 for more information.
- Auto-darkening welding helmets will reduce awkward neck motions associated with lowering traditional hoods. The auto-darkening feature also reduces the likelihood of welding without proper eye protection. Refer to vendor table 4.
- Tool stools or a welding creeper will allow workers to weld at or near floor level in a more neutral posture. Tool stools used in the welding area need to be non-flammable and OSHA approved. Refer to vendor tables 2 and 4.
- A mobile gantry crane would allow for parts needing repairs to be hoisted onto working surfaces and machines. Refer to vendor table 4.
- Welders at another facility reduced risk factors associated with carrying heavy power-cons by building a fixture. Construction and assembly drawings are available. More information is available at:
  http://safetycenter.navy.mil/success/stories/0100.pdf
- An industrial dolly could be used to move the grisley power-cons and other materials. Refer to vendor table 4.
- Cylinder carts and an alligator jaw forklift attachment could be used for moving heavy gas cylinders. Refer to vendor table 4.

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Vendor Table 4- Welding Shop			
Product	Vendor	Estimated Cost	Figure
Auto-darkening helmets	Graigner	$148- $263	
	Lab Safety 1-800-356-0786	$447-$486	
Welding Creeper	Eidos Corp 800 210 9666 Model # 110	$170	
Industrial dolly	Grainger Vending machine truck	$392	
	Global Industrial 1-800-645-1232 Folding Hand Cart	$149	
	C& H 1-800-558-9966	$121-$161	
Gas Cylinder handling equipment	Grainger Cylinder Carts	$150-$300	
	C& H 1-800-558-9966 Double cylinder truck with hand break	$800-$963	

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Vendor Table 4- Welding Shop			
Product	Vendor	Estimated Cost	Figure
	Lab Safety 1-800-356-0786 Poly-cylinder Dollies	$141-$294	
Gantry Crane	Lab Safety 1-800-356-0786 Wesco 2 Ton Gantry Crane 12-15' wide	$1965	
	Grainger 4,000 lb. capacity 14' wide	$1311	
	Global Industrial 1-800-645-1232 8,000 lb capacity 15' wide (14' usable)	$1731	

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Appendix I

Job Requirements and Physical Demands Survey Results

Pump Shop

Summary
The Job Requirements and Physical Demands Survey (JR/PD) was administered to the employees of the pump shop. Information regarding the development, instruction, and validation of the JR/PD can be found at http://www.brooks.af.mil/afioh/Health%20Programs/ergonomics_jrpd.htm. The JR/PD is an ergonomics assessment tool endorsed by the Department of Defense Ergonomic Working Group and used by the tri-services to collection occupational health data. The JR/PD is a survey used to assess ergonomics related risk in the workplace.

The results of the JR/PD indicate pump shop is an Ergonomics Problem Area (EPRA). The pump shop scored an Overall or Survey Priority Rank of **five** (on a scale of 1 to 9), where nine has the highest priority for intervention. A score of five or greater indicates an Ergonomics Problem Area. The JR/PD assesses five distinct body regions: shoulder/neck, hand/wrist/arm, back/torso, leg/foot, and head/eye. The (body region) priority scores are a combination of identified ergonomics risk factors and employee reported discomfort. The shoulder/neck, hand/wrist/arm, back/torso, and leg/foot regions had significant priority scores. A significant number of employees reported experiencing work-related pain or discomfort that does not improve when away from work. Thirty-six percent of the survey respondents have seen a health care provider within the last twelve months for pain or discomfort that he or she feels is related to the job. A significant number of employees also reported pre-existing Musculoskeletal Disorders (MSDs) as well as illnesses recognized as contributing factors, which places them at a higher risk of additional or more severe Work-Related Musculoskeletal Disorders (WMSDs).

Overall Priority Score

The results of the JR/PD indicate the pump shop is an ergonomics problem area with an overall score of **five**. An Overall Job Priority score of five or greater establishes a task/job as an ergonomic problem area. The Overall Job Priority score is determined by selecting the highest Body Region Score for the job which in this case are the shoulder/neck, hand/wrist/arm, back/torso, and leg/foot regions.

The Overall Priority Rating Score is used to determine which jobs or areas are associated with the most significant ergonomic risk. It is important to note that a high Overall Priority Score (i.e. ergonomic problem area) does not necessarily mean that the risk of illness associated with a job or area is high. Rather a high rating indicates that the tasks expose workers to a considerable level of risk factors associated with WMSDs in comparison to jobs/tasks or areas that receive lower scores.

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Demographics

28 (workers/respondents) completed the JR/PD survey, resulting in a 70% response rate. The population demographics are contained in Table 1.

Table 1: Population Demographics

Gender:	Male: 79%	Female: 21%
Group:	Active Duty: 75%	Military Reserve: 4%
Age:	57% between the ages of 21 and 30	
	39% between the ages of 31 and 40	
	4% over the age of 40	

Age is a contributing factor for the development of WMSDs. Totals may not sum to 100% due to under-reporting.

Priority Score

The JR/PD prioritizes five distinct body regions based upon a combination of ergonomics risk factors and discomfort. Workers indicate their duration of exposure for different ergonomics risk factors. Ergonomics risk factors include posture, force, frequency, repetition, vibration, contact stress, and restrictive personal protective equipment. The frequency and severity factors are combined to evaluate discomfort in each of the five body regions. Table 2 demonstrates the relationship between body region, discomfort, and risk.

Table 2 Body Region, Discomfort and Risk

		Body Regions				
		Shoulder/ Neck	Hand/Wrist/Arm	Back/ Torso	Leg/ Foot	Head/ Eye
Priority Score		5	5	5	5	1
Risk	Prevalence	50%	46%	46%	46%	18%
	Rating	Medium	Medium	Medium	Medium	Low
Discomfort	Prevalence	32%	32%	43%	36%	14%
	Rating	Medium	Medium	Medium	Medium	Low

Risk Prevalence and Rating

The percentage of respondents exposed to specific ergonomics risk factors for a given body region, for longer than two hours per day, assesses the prevalence of risk. A low rating represents less than 30% prevalence, medium 31% to 60% and high is greater than 61% of the respondents have exposure greater than 2 hours per day. All of the body regions except head/eye have medium levels of reported risk.

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Discomfort Prevalence and Rating

The terms fatigue, numbness, and pain categorize discomfort. The percentage of respondents and their discomfort ratings determine whether discomfort is prevalent among the workers. Combinations of frequency and severity that indicate significant discomfort prevalence are shown with asterisks in Table 3. Low ratings represent less than 30% prevalence, medium 31% to 60% and high is greater 61%. All of the regions except head/eye reported medium levels of discomfort.

Table 3: Discomfort Matrix

FREQUENCY	SEVERITY		
	Mild	Moderate	Severe
Daily	*	*	*
Weekly		*	*
Monthly			*

The Priority matrix in Table 4 determines the overall prioritization of specific body regions. The relationship between discomfort and risk factors determines priority rating from 1 to 9 for each body region. A priority greater than four, indicated by an asterisk, is significant. The Overall Priority ranking for the pump shop is equal to the highest body region priority value, which is a five. All of the body regions except head/eye had significant scores.

Table 4 Priority Matrix

RISK FACTOR	DISCOMFORT		
	High	Medium	Low
High	9*	7*	4
Medium	8*	5*	2
Low	6*	3	1

Organizational Information

Organizational factors contribute to ergonomic stressors. The organizational score for this area was **low**, which indicates job stress factors are of minimal concern. Survey respondents were asked if they understood their job responsibilities, if their workload was too heavy, if they are able to get pertinent information, if they received comments on performance, etc. Suggestions to improve stress associated with organizational factors include providing workers with more autonomy and improving discussion and feedback between workers and supervisors.

Physical Effort

The survey resulted in a perceived physical exertion score of **8.9**. Respondents were asked to describe the physical effort required of their job on a scale of 1 to 15 where one is no exertion at all and fifteen is maximal exertion. The higher the score, the

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greater the level of perceived physiological exertion. A value of 8 is somewhat hard, indicating a nominally physically demanding task.

Health Care Provider Score

According to the health care provider score, **10 (36%)** of the respondents reported having been to a health care provider in the last 12 months for pain or discomfort that he or she thinks is related to his job.

Recovery Time Score

46% of the respondents reported experiencing work-related pain or discomfort that does not improve when away from work overnight or over the weekend. A score above 30% is of high importance. Lasting pain/discomfort is an indicator of inadequate recovery time for the muscles, tendons, and ligaments. Muscles, tendons, and ligaments that do not recover are more likely to be injured. Significant discomfort is apparent in the workers' inability to recover after the cessation of work.

Activity Interruption Score

35% of the respondents indicated that in the past 12 months, work-related pain or discomfort has caused difficulty in carrying out normal activities (e.g. job, hobby, leisure, etc.). A score above 50% is of high importance.

Previous Diagnosis Score

The survey asks if "a health care provider ever told you that you have any of the following conditions which you think might be related to your work?

Tendonitis/Tenosynovitis	Ganglion Cyst
Trigger Finger,	Epicondylitis (Tennis Elbow)
Bursitis	Carpal Tunnel Syndrome
Thoracic Outlet Syndrome	Back Strain, Knee or Ankle Strain
Overuse Syndrome"	

29% of respondents indicated affirmatively. Pre-existing WMSDs can contribute to an employee's pain and discomfort levels; thereby affecting the overall priority score. Working conditions may exacerbate a pre-existing disorder. Workers with pre-existing WMSDs are likely to experience additional or more severe WMSDs if the environment is unchanged.

Contributing Factors

Respondents were asked if they had ever had one or more of the following conditions:

Wrist Fracture	Hypertension	Kidney Disorders

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Thyroid Disorders Diabetes Gout

Rheumatoid Arthritis

29% of the respondents indicated positively. These health conditions are contributing factors and may increase one's risk of developing a musculoskeletal disorder; thereby affecting overall priority.

Process Improvement Opportunities

This section of the survey allows employees to write in responses to questions. All statements are included exactly as written by the employees with the exception of spelling errors and expletives.

1. Which tasks are the most awkward or require you to work in the most uncomfortable position?
   - ∞ Lifting parts to be machined
   - ∞ Working on machinery that requires you to be bent over for continued periods of time
   - ∞ Work on the floor
   - ∞ Electro plating
   - ∞ Heavy jobs big and hard to move around for machining
   - ∞ Removing installing pumps on ships rebuilding pumps
   - ∞ Fire pumps
   - ∞ Fire pumps
   - ∞ Fire pumps
   - ∞ Changing values in tight spaces
   - ∞ Working on fire pumps in small spaces
   - ∞ Bilge work
   - ∞ Fire pumps
   - ∞ Disconnecting pumps

2. Which tasks take the most effort?
   - ∞ Align pumps/foundation/shaft's
   - ∞ Lifting parts to be machined
   - ∞ Placing material in and out of metal working machinery
   - ∞ Moving equipment to site on ships
   - ∞ Heavy jobs big and hard to move around for machining
   - ∞ Removing installing pumps on ships rebuilding pumps
   - ∞ Fire pumps & sea water circ pump
   - ∞ Fire pumps/sws pumps
   - ∞ Removing valves & valves parts that are corroded
   - ∞ Overhauling equipment
   - ∞ Aligning & installing pumps & motors

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- ∞ Disconnecting pumps

3. Are there any tools or pieces of equipment that are notoriously hard to work with?
   - ∞ Bar stock, pump cases
   - ∞ Bearing puller

4. If you could make any suggestions that would help you do your job more easily or faster or better, what would you suggest.
   - ∞ To get more people in the shop
   - ∞ Lifting equip, overhead cranes
   - ∞ Lifting tables for moving heavy objects to and from metal working machinery
   - ∞ New tools to do jobs faster
   - ∞ Stock material not order it when jobs come in because of this jobs sit for weeks

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Appendix II
Job Requirements and Physical Demands Survey Results
Antenna Shop

Summary
The Job Requirements and Physical Demands Survey (JR/PD) was administered to the employees of the antenna shop. Information regarding the development, instruction, and validation of the JR/PD can be found at http://www.brooks.af.mil/afioh/Health%20Programs/ergonomics_jrpd.htm. The JR/PD is an ergonomics assessment tool endorsed by the Department of Defense Ergonomic Working Group and used by the tri-services to collection occupational health data. The JR/PD is a survey used to assess ergonomics related risk in the workplace.

The results of the JR/PD indicate the antenna shop is an Ergonomics Problem Area (EPRA). The antenna shop scored an Overall or Survey Priority Rank of **seven** (on a scale of 1 to 9), where nine has the highest priority for intervention. A score of five or greater indicates an Ergonomics Problem Area. The JR/PD assesses five distinct body regions: shoulder/neck, hand/wrist/arm, back/torso, leg/foot, and head/eye. The (body region) priority scores are a combination of identified ergonomics risk factors and employee reported discomfort. The back/torso region had a significant priority score. A significant number of employees reported experiencing work-related pain or discomfort that does not improve when away from work and has interrupted normal activities.

Antenna Shop

Overall Priority Score

The results of the JR/PD indicate the antenna shop is an ergonomics problem area with an overall score of **seven**. An Overall Job Priority score of five or greater establishes a task/job as an ergonomics problem area. The Overall Job Priority score is determined by selecting the highest Body Region Score for the job which in this case is the back/torso region.

The Overall Priority Rating Score is used to determine which jobs or areas are associated with the most significant ergonomic risk. It is important to note that a high Overall Priority Score (i.e. ergonomic problem area) does not necessarily mean that the risk of illness associated with a job or area is high. Rather a high rating indicates that the tasks expose workers to a considerable level of risk factors associated with WMSDs in comparison to jobs/tasks or areas that receive lower scores.

Demographics

3 (workers/respondents) completed the JR/PD survey, resulting in a 60% response rate. The population demographics are contained in Table 1.

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Table 1: Population Demographics

Gender:	Male: 100%	Female: 0%
Group:	Active Duty: 100%	
Age:	66% between the ages of 21 and 30	
	33% between the ages of 31 and 40	
	0% over the age of 40	

Priority Score

The JR/PD prioritizes five distinct body regions based upon a combination of ergonomics risk factors and discomfort. Workers indicate their duration of exposure for different ergonomics risk factors. Ergonomics risk factors include posture, force, frequency, repetition, vibration, contact stress, and restrictive personal protective equipment. The frequency and severity factors are combined to evaluate discomfort in each of the five body regions. Table 2 demonstrates the relationship between body region, discomfort, and risk.

Table 2 Body Region, Discomfort and Risk

		Body Regions				
		Shoulder/ Neck	Hand/Wrist/Arm	Back/ Torso	Leg/ Foot	Head/ Eye
Priority Score		4	1	7	4	2
Risk	Prevalence	67%	0%	67%	67%	33%
	Rating	High	Low	High	High	Medium
Discomfort	Prevalence	0%	0%	33%	0%	0%
	Rating	Low	Low	Medium	Low	Low

Risk Prevalence and Rating

The percentage of respondents exposed to specific ergonomics risk factors for a given body region, for longer than two hours per day, assesses the prevalence of risk. A low rating represents less than 30% prevalence, medium 31% to 60% and high is greater than 61% of the respondents have exposure greater than 2 hours per day. The shoulder/neck, back/torso, and leg/foot regions were associated with high levels of risk. The head/eye region was associated with a medium level of risk.

Discomfort Prevalence and Rating

The terms fatigue, numbness, and pain categorize discomfort. The percentage of respondents and their discomfort ratings determine whether discomfort is prevalent among the workers. Combinations of frequency and severity that indicate significant discomfort prevalence are shown with asterisks in Table 3. Low ratings represent less than 30% prevalence, medium 31% to 60% and high is greater 61%. The back/torso was associated with a medium level of discomfort.

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Table 3: Discomfort Matrix

FREQUENCY	SEVERITY		
	Mild	Moderate	Severe
Daily	*	*	*
Weekly		*	*
Monthly			*

The Priority matrix in Table 4 determines the overall prioritization of specific body regions. The relationship between discomfort and risk factors determines priority rating from 1 to 9 for each body region. A priority greater than four, indicated by an asterisk, is significant. The Overall Priority ranking for the antenna shop area is equal to the highest body region priority value, which is a seven. The back/torso region had a significant score.

Table 4 Priority Matrix

RISK FACTOR	DISCOMFORT		
	High	Medium	Low
High	9*	7*	4
Medium	8*	5*	2
Low	6*	3	1

Organizational Information

Organizational factors contribute to ergonomic stressors. The organizational score for this area was **low**, which indicates job stress factors are of minimal concern. Survey respondents were asked if they understood their job responsibilities, if their workload was too heavy, if they are able to get pertinent information, if they received comments on performance, etc. Suggestions to improve stress associated with organizational factors include providing workers with more autonomy and improving discussion and feedback between workers and supervisors.

Physical Effort

The survey resulted in a perceived physical exertion score of **12.3**. Respondents were asked to describe the physical effort required of their job on a scale of 1 to 15 where one is no exertion at all and fifteen is maximal exertion. The higher the score, the greater the level of perceived physiological exertion. A value of 12 is very hard, indicating a very physically demanding task.

Health Care Provider Score

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According to the health care provider score, **none** of the respondents reported having been to a health care provider in the last 12 months for pain or discomfort that he or she thinks is related to his job.

Recovery Time Score

33% of the respondents reported experiencing work-related pain or discomfort that does not improve when away from work overnight or over the weekend. A score above 30% is of high importance. Lasting pain/discomfort is an indicator of inadequate recovery time for the muscles, tendons, and ligaments. Muscles, tendons, and ligaments that do not recover are more likely to be injured. Significant discomfort is apparent in the workers' inability to recover after the cessation of work.

Activity Interruption Score

67% of the respondents indicated that in the past 12 months, work-related pain or discomfort has caused difficulty in carrying out normal activities (e.g. job, hobby, leisure, etc.). A score above 50% is of high importance.

Previous Diagnosis Score

The survey asks if "a health care provider ever told you that you have any of the following conditions which you think might be related to your work?

Tendonitis/Tenosynovitis	Ganglion Cyst
Trigger Finger,	Epicondylitis (Tennis Elbow)
Bursitis	Carpal Tunnel Syndrome
Thoracic Outlet Syndrome	Back Strain, Knee or Ankle Strain
Overuse Syndrome"	

0% of respondents indicated affirmatively. Pre-existing WMSDs can contribute to an employee's pain and discomfort levels; thereby affecting the overall priority score. Working conditions may exacerbate a pre-existing disorder. Workers with pre-existing WMSDs are likely to experience additional or more severe WMSDs if the environment is unchanged.

Contributing Factors

Respondents were asked if they had ever had one or more of the following conditions:

Wrist Fracture	Hypertension	Kidney Disorders
Thyroid Disorders	Diabetes	Gout
Rheumatoid Arthritis		

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0% of the respondents indicated positively. These health conditions are contributing factors and may increase one's risk of developing a musculoskeletal disorder; thereby affecting overall priority.

Process Improvement Opportunities

This section of the survey allows employees to write in responses to questions. All statements are included exactly as written by the employees with the exception of spelling errors and expletives.

1. Which tasks are the most awkward or require you to work in the most uncomfortable position?
   - 1.) Carrying 2537 antennas 2.) Blasting 3.) 1735 antennas, install, transport
   - Removal of AS-1735, Blasting all antenna carrying AS-2537

2. Which tasks take the most effort?
   - 1.) Blasting 2.) 1735 antennas, install, transport 3.) Carrying 2537's, 3772's 4.) Disassemble 2537's, 3772's
   - Install 1735, Blasting antenna, carry 2537

3. Are there any tools or pieces of equipment that are notoriously hard to work with?
   - Blast booth
   - Blast booth

4. If you could make any suggestions that would help you do your job more easily or faster or better, what would you suggest?
   - 1.) Automated blasting 2.) Crane service for 1735's 3.) Platforms on ships for easier access to work on antennas 3.) Carts to transport 2537's, 3772's

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Appendix III
Job Requirements and Physical Demands Survey Results
Welding Shop

Summary
The Job Requirements and Physical Demands Survey (JR/PD) was administered to the employees of the welding shop. Information regarding the development, instruction, and validation of the JR/PD can be found at http://www.brooks.af.mil/afioh/Health%20Programs/ergonomics_jrpd.htm. The JR/PD is an ergonomics assessment tool endorsed by the Department of Defense Ergonomic Working Group and used by the tri-services to collection occupational health data. The JR/PD is a survey used to assess ergonomics related risk in the workplace.

The results of the JR/PD indicate the welding shop is an Ergonomics Problem Area (EPRA). The welding area scored an Overall or Survey Priority Rank of **nine** (on a scale of 1 to 9), where nine has the highest priority for intervention. A score of five or greater indicates an Ergonomics Problem Area. The JR/PD assesses five distinct body regions: shoulder/neck, hand/wrist/arm, back/torso, leg/foot, and head/eye. The (body region) priority scores are a combination of identified ergonomics risk factors and employee reported discomfort. The shoulder/neck, hand/wrist/arm, and back/torso regions were associated with significant scores, but the back/torso region was the highest. A significant number of employees reported experiencing work-related pain or discomfort that does not improve when away from work and has interfered with normal acitivities. Thirty-eight percent of the survey respondents have seen a health care provider within the last twelve months for pain or discomfort that he or she feels is related to the job. A significant number of employees also reported pre-existing Musculoskeletal Disorders (MSDs) as well as illnesses recognized as contributing factors, which places them at a higher risk of additional or more severe Work-Related Musculoskeletal Disorders (WMSDs).

Welding

Overall Priority Score

The results of the JR/PD indicate the welding area is an ergonomics problem area with an overall score of **nine**. An Overall Job Priority score of five or greater establishes a task/job as an ergonomic problem area. The Overall Job Priority score is determined by selecting the highest Body Region Score for the job which in this case is the back/torso region.

The Overall Priority Rating Score is used to determine which jobs or areas are associated with the most significant ergonomic risk. It is important to note that a high Overall Priority Score (i.e. ergonomic problem area) does not necessarily mean that the risk of illness associated with a job or area is high. Rather a high rating indicates that

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the tasks expose workers to a considerable level of risk factors associated with WMSDs in comparison to jobs/tasks or areas that receive lower scores.

Demographics

8 (workers/respondents) completed the JR/PD survey, resulting in a 100% response rate. The population demographics are contained in Table 1.

Table 1: Population Demographics

Gender:	Male: 88%	Female: 12%
Group:	88% Active Duty	13% Military Reserve
Age:	13% under the age of 20	
	51% between the ages of 21 and 30	
	13% between the ages of 31 and 40	
	25% over the age of 40	

Age is a contributing factor for the development of WMSDs.

Priority Score

The JR/PD prioritizes five distinct body regions based upon a combination of ergonomics risk factors and discomfort. Workers indicate their duration of exposure for different ergonomics risk factors. Ergonomics risk factors include posture, force, frequency, repetition, vibration, contact stress, and restrictive personal protective equipment. The frequency and severity factors are combined to evaluate discomfort in each of the five body regions. Table 2 demonstrates the relationship between body region, discomfort, and risk.

Table 2 Body Region, Discomfort and Risk

		Body Regions				
		Shoulder/ Neck	Hand/Wrist/Arm	Back/ Torso	Leg/ Foot	Head/ Eye
Priority Score		7	8	9	4	1
Risk	Prevalence	75%	50%	63%	75%	25%
	Rating	High	Medium	High	High	Low
Discomfort	Prevalence	50%	63%	63%	25%	25%
	Rating	Medium	High	High	Low	Low

Risk Prevalence and Rating

The percentage of respondents exposed to specific ergonomics risk factors for a given body region, for longer than two hours per day, assesses the prevalence of risk. A low rating represents less than 30% prevalence, medium 31% to 60% and high is greater than 61% of the respondents have exposure greater than 2 hours per day. The shoulder/neck, back/torso and leg/foot have high reported levels of risk and hand/arm/wrist is medium.

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Discomfort Prevalence and Rating

The terms fatigue, numbness, and pain categorize discomfort. The percentage of respondents and their discomfort ratings determine whether discomfort is prevalent among the workers. Combinations of frequency and severity that indicate significant discomfort prevalence are shown with asterisks in Table 3. Low ratings represent less than 30% prevalence, medium 31% to 60% and high is greater 61%. The hand/arm/wrist and back/torso have high reported levels of discomfort and shoulder/neck is medium.

Table 3: Discomfort Matrix

FREQUENCY	SEVERITY		
	Mild	Moderate	Severe
Daily	*	*	*
Weekly		*	*
Monthly			*

The Priority matrix in Table 4 determines the overall prioritization of specific body regions. The relationship between discomfort and risk factors determines priority rating from 1 to 9 for each body region. A priority greater than four, indicated by an asterisk, is significant. The Overall Priority ranking for the welding area is equal to the highest body region priority value, which is a nine. The shoulder/neck, hand/arm/wrist and back/torso regions have significant priority scores.

Table 4 Priority Matrix

RISK FACTOR	DISCOMFORT		
	High	Medium	Low
High	9*	7*	4
Medium	8*	5*	2
Low	6*	3	1

Organizational Information

Organizational factors contribute to ergonomic stressors. The organizational score for this area was **low**, which indicates job stress factors are of minimal concern. Survey respondents were asked if they understood their job responsibilities, if their workload was too heavy, if they are able to get pertinent information, if they received comments on performance, etc. Suggestions to improve stress associated with organizational factors include providing workers with more autonomy and improving discussion and feedback between workers and supervisors.

Physical Effort

The survey resulted in a perceived physical exertion score of **9.3**. Respondents were asked to describe the physical effort required of their job on a scale of 1 to 15 where

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one is no exertion at all and fifteen is maximal exertion. The higher the score, the greater the level of perceived physiological exertion. A value of 8 is somewhat hard, indicating a nominally physically demanding task.

Health Care Provider Score

According to the health care provider score, 3 **(38%)** of the respondents reported having been to a health care provider in the last 12 months for pain or discomfort that he or she thinks is related to his or her job.

Recovery Time Score

38% of the respondents reported experiencing work-related pain or discomfort that does not improve when away from work overnight or over the weekend. A score above 30% is of high importance. Lasting pain/discomfort is an indicator of inadequate recovery time for the muscles, tendons, and ligaments. Muscles, tendons, and ligaments that do not recover are more likely to be injured. Significant discomfort is apparent in the workers' inability to recover after the cessation of work.

Activity Interruption Score

50% of the respondents indicated that in the past 12 months, work-related pain or discomfort has caused difficulty in carrying out normal activities (e.g. job, hobby, leisure, etc.). A score above 50% is of high importance.

Previous Diagnosis Score

The survey asks if "a health care provider ever told you that you have any of the following conditions which you think might be related to your work?

Tendonitis/Tenosynovitis	Ganglion Cyst
Trigger Finger,	Epicondylitis (Tennis Elbow)
Bursitis	Carpal Tunnel Syndrome
Thoracic Outlet Syndrome	Back Strain, Knee or Ankle Strain
Overuse Syndrome"	

38% of respondents indicated affirmatively. Pre-existing WMSDs can contribute to an employee's pain and discomfort levels; thereby affecting the overall priority score. Working conditions may exacerbate a pre-existing disorder. Workers with pre-existing WMSDs are likely to experience additional or more severe WMSDs if the environment is unchanged.

Contributing Factors

Respondents were asked if they had ever had one or more of the following conditions:

Wrist Fracture	Hypertension	Kidney Disorders

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Thyroid Disorders Diabetes Gout

Rheumatoid Arthritis

38% of the respondents indicated positively. These health conditions are contributing factors and may increase one's risk of developing a musculoskeletal disorder; thereby affecting overall priority.

Process Improvement Opportunities

This section of the survey allows employees to write in responses to questions. All statements are included exactly as written by the employees with the exception of spelling errors and expletives.

1. Which tasks are the most awkward or require you to work in the most uncomfortable position?
   - ∞ Welding in a overhead position
   - ∞ Using shoulder
   - ∞ Lifting very heavy equipment
   - ∞ Overhead work: cutting prepping, and welding
   - ∞ Taking out trash
   - ∞ Grinding
   - ∞ Working in tight positions on corners
   - ∞ Grinding in an awkward position
   - ∞ Welding
   - ∞ Notching large 1/8" pieces of metal on the "universal iron worker"

2. Which tasks take the most effort?
   - ∞ Welding inside a gas turbine module
   - ∞ Using my shoulder
   - ∞ Lifting very heavy equipment
   - ∞ Using the band saw
   - ∞ Grinding
   - ∞ Carrying full argon bottles to ship then up 3-5 decks up along with heavy equipment
   - ∞ Moving metal for (cutting, putting in rack)
   - ∞ Notching out scribed patterns

3. Are there any tools or pieces of equipment that are notoriously hard to work with?
   - ∞ 440 extension cords longer than 25 ft.
   - ∞ Grinder
   - ∞ MIG gun doing overhead welding

4. If you could make any suggestions that would help you do your job more easily or faster or better, what would you suggest?

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- 440 ext cord should be at least 150 ft
- Cut down on stupid pointless jobs
- More lean training
- No grinding
- Have more smaller argon bottles (pony) instead of 5' ones
- Making the work benches higher so you don't have to bend over for long periods of time working over a project

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Appendix IV

Engine Shop

The Job Requirements and Physical Demands Survey was administered to the employees of the engine shop. While the survey results were not significant the process improvement opportunities are included below.

Process Improvement Opportunities

This section of the survey allows employees to write in responses to questions. All statements are included exactly as written by the employees with the exception of spelling errors and expletives.

1. Which tasks are the most awkward or require you to work in the most uncomfortable position?
   - Working in tight places when there are pumps piping in your way
   - During a overhaul
   - 149 Overhauls
   - Overhaul jobs
   - Moving heavy objects APU parts
   - Engine overhaul on Dertroit Diesel
   - Detroit 149 Diesel engine on FFG Class (Frigate's), overhaul, generator seals, 40 pump, coming to work
   - 149 overhauls
   - Engine overhauls
   - Working in the Aframe of a 149 eng & working on APUs
   - 149 Detroit O/H, sack O/H, APU O/H

2. Which tasks take the most effort?
   - Rebuilding an 1149 Detroit
   - Overhaul
   - Entire evolution
   - Lubricating pump, engine block installation
   - A.P.U
   - Overhauls
   - Generator seals especially on 4 Diesel FFG Class, 40 pump, main bearing caps, can rod bearing caps, SAC (Start Air Compressor)
   - Engine overhauls
   - Rigging E24 blocks off ships & pushing APU through the building
   - 149 Detroit O/H, APU O/H

3. Are there any tools or pieces of equipment that are notoriously hard to work with?
   - Wrench
   - APU's

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- ∞ Hand tools

4. If you could make any suggestions that would help you do your job more easily or faster or better, what would you suggest?
   - ∞ Have parts on time
   - ∞ Parts to be on time
   - ∞ Phurnetic? Tools
   - ∞ More personnel
   - ∞ More personnel
   - ∞ 1.) Knee pads 2.) More tools to cut or specifically to make easier with the specific space working with
   - ∞ Manufacture a new style of cradle. For APU to roll in or out of building without being a safety hazard.
   - ∞ Air tools

End Notes:

[1] Equipment purchase without proper and repeated training will not mitigate risk and may in fact increase hazards.

[2] Administrative controls are management-controlled work practices and policies designed to reduce exposures to work-related musculoskeletal disorders (WMSDs) hazards by changing the way work is assigned or scheduled. Administrative controls reduce the exposure to ergonomic stressors and thus reduce the cumulative dose to any one worker. Examples of administrative controls that are used in the ergonomics context are employee rotation, employer-authorized changes in the pace of work and team lifting.

[3] This report does not constitute an endorsement of any particular product. Rather, it is a recitation of how Navy personnel have addressed a particular work place safety issue. Neither the Navy nor its employees and agents, warrant any product described in this report for any use, either general or particular.

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