

**Advanced Composite Shop, Shipping and Receiving,  
and Storage Areas**

Ergonomic Risk Assessment Navy Facilities East Division

An ergonomic survey was conducted on March 27 and 28, 2000. The Advanced Composite Shop, Shipping and Receiving, and storage areas were observed in order to determine sources of ergonomic stress. This assessment is based upon interviews with employees, supervisors, and safety personnel as well as evaluation by the Hazard Abatement East Coast occupational ergonomist. The Job Requirements and Physical Demands Survey (JRPD), an ergonomic survey, was also administered to the employees. The results of the JRPD indicate that the Advanced Composite Shop, NIF Storage Areas, and Receiving and Distribution areas of the Fuel Control Facility are Ergonomic Problem Areas. Recommendations are included with as much vendor information as possible to assist in the evaluation of products and services.

## I. Advanced Composite Shop

### Background

The Advanced Composite Shop employs 55 artisans over three shifts. There have been three recorded injuries in this shop. During the evaluation, employees noted that the most difficult tasks in the shop are loading autoclaves, sanding adhesives, blasting in the blast booth, and moving large, heavy carts and tables. The employees are responsible for the evaluation and repair of composite airplane parts. Three operations were evaluated in this shop: loading and unloading of autoclaves, blasting, and working at standing workstations.

The JRPD was administered to employees in the Advance Composite Shop. The survey results indicate that this operation is an Ergonomic Problem Area (EPRA) with an overall priority score of 8 (on a scale of 1-9, where 9 has the greatest priority). Significant amounts of discomfort and ergonomic risk were found in the leg/torso, back/torso, hand/wrist/arm, and shoulder/neck regions. JRPD results also indicate that employees are experiencing work related pain or discomfort, which does not improve away from work and has interfered with carrying out normal activities. Research indicates that discomfort not relieved by rest has a high probability of resulting in a work related musculoskeletal disorder (WMSDs). According to the ergonomic survey, a significant number of employees have been diagnosed with a Cumulative Trauma Disorder such as Tendonitis, Carpal Tunnel Syndrome, Bursitis, etc. that the employee feels is related to work. Other risk factors for musculoskeletal disorders found through the survey include pre-existing conditions and health problems as well as organizational issues. The specific results of the JRPD are contained in Appendix I for reference.

## Autoclave Process

The most difficult task in this shop is the loading and unloading of parts into autoclaves for curing. There are four autoclaves (A through D), which cure parts for 6 to 8 hours at a time. Employees push carts carrying parts to the autoclaves for loading and unloading. Carts can weigh up to 2,000 pounds. Pushing carts can require up to three artisans at a time. The extreme weight of the carts puts the employees at risk of injury.

All four autoclaves have different methods of loading and unloading. Parts are brought to Autoclave A by cart. The operator then has to bend over inside the autoclave and pull the parts in, as shown in figure 1. Pulling parts from a crouched position with a bent back and extended arms places stress on the legs, back, shoulders, and arms.

Autoclave B is larger than A and uses a dual ram elevating platform to lift the table to the height of the autoclave. The table is then pushed into the autoclave. Pushing heavy carts places severe strain on the back and shoulders. The dual ram lift has no safety rails. If the cart is not fully centered on the lift it will roll. A 2,000-pound cart falling from a height of about 3 feet poses an extreme safety hazard and could result in a crushing injury. There is also a personnel trip and fall hazard associated with pulling the cart out of autoclave while walking backward onto the lift platform which is elevated off the floor, figures 2 and 3.

Autoclave C is loaded with a split-level cart. The cart's tabletop is on wheels and can be pushed into the autoclave on guide rails. This cart is still very heavy and requires extreme force in moving, refer to figure 4.

Autoclave D, shown in figure 5, is a small autoclave used for smaller, lighter parts. This autoclave doesn't pose any major ergonomic hazards.

## Photos removed

Figure 1: Loading Autoclave A

Figure 2: Unloading Autoclave B onto dual ram lift, employees walk backward toward edge of platform

Figure 3: Unloading cart from Autoclave B's Lift Platform

Figure 4: Unloading split level cart from Autoclave C

Figure 5: Autoclave D

## Recommendation:

### **Split-Level Carts**

The extreme weight of the current carts combined with the awkward postures required in loading and unloading autoclaves places the employees at risk of developing musculoskeletal disorders as well as other safety hazards. Lightweight, split-level carts are recommended for autoclaves A, B, and C. The top of a split-level cart can be loaded with parts and pushed directly into autoclave A; thereby eliminating the need for the employee to enter the autoclave and pull the parts in. Since the height of the split-level cart can be equal to the autoclave load height, the elevating platform at autoclave B can be removed. The employees are currently at risk of falling off this platform or being crushed by a falling cart. Autoclave C currently uses a split-level cart, but would benefit from a lighter model to reduce the force required in moving the cart.

Each cart is approximately \$15,000 to \$25,000 and will have to be designed specifically for each autoclave. Contact Karin Lown at American Autoclave Company to work out the engineering design details (253-863-5000). Depending on the design criteria it may be possible to outfit the cart with a winch to pull the split-level table out of the autoclave and eliminate heavy pulling.

### **Blasting Process**

Employees sandblast parts for up to 6 hours at a time. Employees place parts inside the blaster and then stand on a platform with their hands in gloves while watching through a window. The height of the windows and the openings for the gloves are not adjustable. The work heights of each of the four blast machines differ by as much as 12". Given the individual size differences among the employee population, operators are forced into extremely awkward postures for extended periods of time, as shown in figures 6 and 7. The duration of the blasting process may cause fatigue, muscle strain and cramping as well as cumulative trauma.



Figure 6: Blast machine use



Figure 7: Blast machine use

**Recommendations:****Platforms**

The height of the windows and armholes in the blasting machines are fixed. Operators can adjust their work height by adding or subtracting modular work platforms in order to encourage neutral work heights. Platforms are available in different sizes. The optional anti-fatigue matting for the platforms would help reduce operator fatigue associated with standing for long periods of time. A new blast booth may be a future consideration.

<b>Table 1: Platform Recommendations</b>		
Vendor	Product	Price
C&H 1-800-558-9966	Add-A-Level	\$37.90 each 2'x3'
Global 1-800-645-1232	Stackable Platform Optional Anti-fatigue matting	\$34.95 each 2'x3' \$43.95

**Seating**

Allowing the operators to sit while blasting would also help reduce fatigue. Due to a lack of legroom and limited reaching abilities, a feasible chair may be difficult to find. If possible, seating options should be obtained for trial evaluation while gathering employee feedback. An optimal solution would allow employees to alternate between standing and sitting while blasting. One seating option is a Sit/stand stools which keep the operator at a similar height as standing but allow resting of the back and legs by leaning against the stool. Chairs are not recommended on platforms.

<b>Table 2: Seating Recommendations</b>		
Vendor	Product	Price
Alimed 1-800-225-2610	Portable Sit/Stand	\$299
Alimed 1-800-225-2610	Stand Stool RA75195	\$243
Global Industrial 1-800-645-1233	Lyon Sit-Stand Stool XF244849	\$223
C&H 1-800-336-1331	Lyon Sit-Stand Stool 41-186D	\$219
C&H 1-800-336-1331	Workspace Sit/Stand Stool 41-340A	\$190
Laura Hambrech 904-269-0658 GSA #GS29F0274H	Hag Capisco Chair* 8106 with extended pneumatic lift and foot ring	\$442

\*The Hag Capisco chair is straddled so that the person is leaning on the backrest as front support. The HAG vendor is local to NADEP Jax and will supply samples for trial.



Sit/Stand Stool



HAG Capisco

## Standing Workstations

A lot of the equipment used in this shop has been acquired from disposal areas and was not designed for its current use. Airplane wings are currently being transported on carts with foam taped around the cart handles, as shown in figure 8. Figure 9 shows an airplane part placed on a non-adjustable workbench. In addition, operators working at a workbench stand directly on the concrete floor, which can cause fatigue over extended periods of time. The operator is unable to sit at the workbench due to a lack of knee clearance. Some of the workbenches are not equipped with fixtures to hold parts, so the operator has to assume awkward arm postures in order to work on the part directly on the workbench, as shown figure 10. Figure 11 also shows an operator with awkward postures in the upper extremities because a part is placed on a flat surface, in this case the bottom of a sink. Working with raised arms places stress on the arms and shoulders and can lead to cumulative trauma and fatigue.

Photos removed

Figure 8: Cart for transporting parts    Figure 9: Workbench



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Figure 10: Working on a part on a flat surface

Figure 11: Working at a wash station

**Recommendations:****Height Adjustable Carts**

Operators commonly work at standing workstations in awkward postures due to a lack of fixtures and non-adjustability of the work surface. Height adjustable carts with fixtures for holding and orienting parts will allow employees to work at neutral heights. Cart size depends on part size. Multiple carts will be necessary.

<b>Table 3: Cart Recommendations</b>		
Vendor	Product	Price
Alimed 1-800-225-2610	Hydraulic Elevating Carts and Lift Tables	\$449-\$800
C&H 1-800-558-9966	Scissor Lift Tables	\$560-\$1320
Lab Safety 1-800-543-9910	Scissor Lift Carts or Lift Tables	\$462-1352
Alzar GSA 260199, 272770, 260200	Mobile Scissor Lift Tables	\$298-\$468
Global Industrial 1-800-645-1232	Mobile Scissor Lifts or Hydraulic Lift Tables	\$329-\$1047
Vestil 1-800-348-0868	Deck Cart, Hydraulic Cart, or Post Table	\$250-1775

**Height Adjustable Workstations**

Height adjustable workstations also provide neutral work heights and reduce awkward postures while accommodating workers of all sizes.

<b>Table 4: Workstation Recommendations</b>		
Vendor	Product	Price
Alimed 1-800-225-2610	Hand Crank Adjustable Height Work Tables	\$805-\$1,325
New Dominion 1-800-850-8559 X132	Hand Crank Adjustable Height Table	\$1,123-\$1,325
Lab Safety 1-800-356-0783	Adjustable Workbenches	\$1018-\$1190
Vestil 1-800-348-0868	Adjustable Work Benches	\$965 (30"x60")

### **Anti-Fatigue Matting**

Anti-fatigue matting reduces pain and discomfort associated with standing for extended periods of time.

<b>Table 5: Anti-Fatigue Matting</b>		
Vendor	Product	Price
Global Industrial 1-800-645-1232	Anti-fatigue matting	\$11-\$225
Alimed 1-800-225-2610	Anti-fatigue matting	\$17-\$100
C&H 1-800-558-9966	Anti-fatigue matting	\$15-\$255
Lab Safety 1-800-348-0869	Anti-fatigue matting	\$15-\$230
Matting World 1-800-257-8557	Anti-fatigue matting	\$15-\$200

### **Fixtures**

Fixtures or jigs to angle parts toward the operator, as demonstrated in figure 12, reduce bending of the neck and back as well as awkward elbow and shoulder postures. A fixture can sometimes even replace the work bench and allow the operator to work at a lower height, possibly while seated. The wash stations, carts, blast machines, and workbenches would benefit from fixtures. These parts can be produced in-house.

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Figure 12: Part angled toward the operator

## II. Storage Area

### Background

There are currently two employees in the storage area working 60 hours a week. One employee performs all of the responsibilities of her job, but uses an electric wheelchair to travel around the building due to a pinched sciatic nerve. This same employee was recently injured again reaching to the back of the pallet shelves. A third employee works a later shift.

The JRPD was administered to employees in the Storage Area. The survey results indicate that this operation is an Ergonomic Problem Area (EPRA) with an overall priority score of 9 (on a scale of 1-9, where 9 has the greatest priority). Significant amounts of discomfort and ergonomic risk were found in all five evaluated body regions: the leg/torso, back/torso, hand/wrist/arm, head/eye, and shoulder/neck areas. JRPD results also indicate that employees are experiencing work related pain or discomfort, which doesn't improve away from work and has interfered with carrying out normal activities. Research indicates that discomfort not relieved by rest has a high probability of resulting in a work related musculoskeletal disorder. According to the ergonomic survey, all of the employees have been diagnosed with a Cumulative Trauma Disorder, such as Tendonitis, Carpal Tunnel Syndrome, Bursitis, etc. that the employee feels is related to work. Other risk factors for Musculoskeletal disorders found through the survey include pre-existing conditions and health problems as well as organizational issues. Working in the storage area is physically demanding, is apparent by the employees classifying their job as very hard. The specific results of the JRPD are contained in Appendix II for reference.

## Storage Process

Employees are responsible for issuing and receiving airplane assembly parts. Parts come into the storage area in hampers (figure 1), carts (figure 2), or by pallet. Employees have to reach over the sides of the hampers to retrieve boxes, placing strain on the shoulders and back.

The storage area consists of rows of storage units and one wall of pallet shelves. There is currently not enough storage in this area and parts are stored in boxes on top of the storage units as shown in figure 3. These boxes are unsupported and pose a safety hazard. There is not enough room between the rows of storage units for the drawers to be pulled out. Employees must bend down to the floor and reach above shoulder height to access drawers of parts, as shown in figure 4. Bending and reaching can place strain on the back and upper extremities. The wall of pallet shelves stores larger boxes. Employees have to climb onto the shelves to reach boxes in the back. Higher shelves require the operator to climb up and down a ladder while carrying boxes, which increases the risk of falling. Figure 5 shows an employee twisting her torso to retrieve a box while maintaining her balance on the ladder. Lifting while twisting increases the stress placed upon the spine.



Figure 1: Emptying boxes from hamper



Figure 2: Cart of incoming boxes



Figure 3: Boxes stored on top of shelving units



Figure 4: Reaching into drawer



Figure 5: Employee reaching for box on upper shelf

**Recommendations:**

**Automated Vertical Retrieval System**

Automatic Vertical Retrieval systems will allow the employees to maintain neutral work heights, neutral postures, and eliminate carrying loads up and down ladders. Sufficient storage will also eliminate the boxes stacked on top of the current storage system.

Quotes need to be obtained from the individual vendors

Remstar, 1-800-639-5805

White 615-793-2558 (Gary Taylor)

Kardex - \$99,000 (quote obtained by NADEP)

**Hamper**

The current plastic hamper should be replaced with one with an elevating base to eliminate bending and reduce back strain. The elevating base raises as packages are emptied.

<b>Table 1: Hamper Recommendations</b>		
Vendor	Product	Price
Postal Products Unlimited 1-800-229-4500	Elevated Basket Truck	\$70-\$85
Postal Products Unlimited 1-800-229-4500	Basket Truck Elevated Spring Platform	\$129-\$218 \$36-\$61
Postal Products Unlimited 1-800-229-4500	Heavy-Duty Spring Loaded Mail Cart	\$349
Grainger	Mail Hamper Spring Platform	\$182-\$335 \$144-\$151
Datamation Systems, Inc 1-201-732-3824	Ergonomic Auto Level Cart	\$935
Charnstrom 1-800-328-2962	Mail Hamper Spring Platform	\$198-\$274 \$60-100



Mail Hamper with Spring Platform  
(Platform moves independently)



Elevated Basket Truck  
(The entire hamper elevates)

### Moving Shelf Ladder

If the large pallet storage racks are not replaced with an automated retrieval system, a moving shelf ladder is recommended. A DC-powered moving shelf ladder allows the employee to place a load on the shelf instead of carrying it up and down the ladder by hand. With the moving shelf ladder, the shelf safely lowers the item to the floor. The order picker allows for a greater range of working heights than the moving shelf ladder, since the operator and the shelf are raised and lowered together. Price depends on ladder height. The ladder height should be determined by the height required to reach loads on the top shelf.

<b>Table 2: Moving Shelf Ladder Recommendations</b>		
Vendor	Product	Price
C&H 1-800-336-1331	Moving Shelf Ladder	\$3148-\$3811
Global Industrial 1-800-645-2986	Powered Shelf Ladder	\$2148-\$3186
Lab Safety 1-800-356-0783	One-Step Entry Order Picker	\$4031.25



Moving Shelf Ladder



Order Picker

### **III. Receiving and Distribution**

#### **Background**

There are currently 8 employees in the dock operation and storage area. Employees can work up to 60 hours a week. The dock is used for receiving and distribution of fuel controls arriving for repair. The storage area is used for repair components.

The JRPD was administered to employees in the Receiving and Distribution areas. The survey results indicate that this operation is an Ergonomic Problem Area (EPRA) with an overall priority score of 5 (on a scale of 1-9, where 9 has the greatest priority). Significant amounts of discomfort and ergonomic risk were found in the shoulder/neck area. JRPD results also indicate that employees are experiencing work related pain or discomfort, which doesn't improve away from work and has interfered with carrying out normal activities. Research indicates that discomfort not relieved by rest has a high probability of resulting in a work related musculoskeletal disorder. Other risk factors for Musculoskeletal disorders found through the survey include pre-existing conditions and health problems as well as organizational issues. The specific results of the JRPD are contained in Appendix III for reference.

## Receiving and Distribution Process

Fuel controls come to Building 795 for repairs and distribution. Fuel controls and repair parts come and go through the dock, requiring repetitive material handling and heavy lifting. Items arrive by Buddha truck, figure 1, or by forklift in wire and plastic baskets on pallets. Incoming Buddha trucks are emptied by hand into pallets of baskets stored on the floor or onto shelves placed around the walls of the dock. Parts are then removed from the shelves and baskets and placed on carts to be taken for evaluation, as shown in figure 2. After evaluation and processing, completed fuel controls return to the dock for distribution. Outgoing fuel controls are unloaded from carts and placed into baskets. Loading and unloading fuel controls from baskets at low heights and high shelves places stress on the back, knees, and upper extremities. Employees spend up to an hour a day loading baskets with outgoing fuel controls and about 6 hours a day unloading baskets of incoming fuel controls. Pallets are placed on the dock wherever there is room, refer to figure 3. It is often unclear which pallets are ready for distribution and which have just been received. Empty pallets are often stuck in the middle of the dock, which makes them inaccessible and takes up valuable dock space. Employees often have to move multiple pallets by hand to access the desired pallet.

There are 30-40 carts in the entire area and about 12 of which are height adjustable. Some of the carts end up being used for long-term storage and are unavailable. Parts can weight up to 70 pounds and average about 30 pounds. The NIOSH Lifting Index was used to calculate the Recommended Weight Limit for unloading parts from baskets into carts. According to the NIOSH Lifting Index, the recommended weights are 12.6 and 9.8 pounds for this lift. The actual weight of the parts far exceeds the recommended limit, which places the employees at risk of back injury.

All fuel controls brought in from the dock are inspected to determine the level of rework required. Controls either go to the shop for repairs or into temporary storage to await other materials for building a repair kit. The storage area has rows of fixed height shelving. The tallest shelf is 87" and the lowest is 1.5". Parts range from 8 oz. to 55 lbs. Employees accessing the top storage shelves have to reach above shoulder height to access boxes, as shown in figure 4. Reaching above shoulder height places an employee at risk of shoulder injury. Employees have to kneel or bend over to reach the bottom shelves, which can place strain on the back and knees. Employees have a locking step stool and a ladder for assistance. Use of step stools is not encouraged since it may create fall and trip hazards. Three employees stock shelves from 1 to 6 hours a day, usually 3 or 4 hours. Employees are also responsible for maintaining inventory information on a computer system.



Figure 1: Buddha Truck



Figure 2: Wire baskets on pallets and cart for transporting parts



Figure 3: Pallets filling the dock



Figure 4: Employee reaching for parts

**Recommendations:****Conveyor**

The current congestion and disorganization of baskets on the dock is hindering material flow. Two separate lanes of roller conveyors for the pallets would stabilize incoming and outgoing traffic flow and improve productivity. Empty pallets could be easily removed at each end. Fork lifts or pallet lifters will be required to load pallets onto the conveyor. The height of the conveyor would reduce ergonomic stressors associated with bending to load and unload baskets by encouraging neutral working heights. A height adjustable conveyor system is preferred.

<b>Table 1: Conveyor Recommendations</b>		
Vendor	Product	Price
New Dominion 1-800-850-8559 X132	Pro-Line pop up ball transfer table	\$1,103-\$1,558
New Dominion 1-800-850-8559 X132	Pro-Line height adjustable retractable ball transfer station	\$1,419-\$1,756
New Dominion 1-800-850-8559 X132	Ball Transfer Table	\$30-\$444 per foot
C&H 1-800-558-9966	Steel Pallet Conveyor H-Stand for Conveyor	\$388.70 \$50-\$60
C&H 1-800-558-9966	Ball Transfer Table H-Stand	\$125-\$865 \$34-\$46
Global Industrial 1-800-645-1232	Ball Transfer Table Permanent Leg Supports	\$119-\$825 \$31-\$85

**Pallet Mover**

A height adjustable pallet mover would allow for loading of the baskets directly onto the conveyor. A height adjustable pallet mover would also allow pallets to be raised to a more neutral height for loading and unloading.

<b>Table 2: Pallet Mover Recommendations</b>		
Vendor	Product	Price
C&H 1-800-558-9966	Pallet Lifter	\$710-\$1318
Alzar Lift GSA Contract	Pallet Lifter	\$432-\$534
Global Industrial 1-800-645-1232	Pallet Lifter	\$675-1200

### Height Adjustable Carts

Height adjustable carts will allow employees to work at neutral heights when loading and unloading baskets and reduce the distance the parts are lifted. Parts currently sitting on carts for long periods of time instead of being placed on shelving, should be moved to storage units. Parts should never be stored for extended periods of time on the height adjustable carts in particular.

Figure 5 shows an employee lifting a load from a table and twisting her torso to place the load on a cart behind her. Twisting while lifting increases the biomechanical loading of the spine. When using height adjustable carts, place the cart perpendicular to the table being unloaded and slide the part onto the cart.



Figure 5: Employee loading a cart

<b>Table 3: Height Adjustable Table Recommendations</b>		
Vendor	Product	Price
Alimed 1-800-225-2610	Hydraulic Elevating Carts and Lift Tables	\$449-\$800
C&H 1-800-558-9966	Scissor Lift Tables	\$560-\$1320
Lab Safety 1-800-543-9910	Scissor Lift Carts or Lift Tables	\$462-1352
Alzar GSA 260199, 272770, 260200	Mobile Scissor Lift Tables	\$298-\$468
Global Industrial 1-800-645-1232	Mobile Scissor Lifts or Hydraulic Lift Tables	\$329-\$1047
Vestil 1-800-348-0868	Deck Cart, Hydraulic Cart, or Post Table	\$250-1775

### **Covered Outside Storage Area**

A covered storage area would temporarily accommodate pallets that can't fit on the dock. Currently these extra pallets are placed in the dock's driveway, which forces the employees emptying the buddha trucks to walk over them. A simple platform off the driveway on the grassy area to either side of the dock, a few inches off the ground with a covering would provide designated storage for pallets. This would protect parts from the elements and decrease some of the dock congestion. This product could be manufactured in-house.

### **Automated Vertical Retrieval System**

Automatic vertical storage units in the storage area would allow the employee to store and retrieve parts from a neutral working height and eliminate reaching to top shelves and bending to bottom shelves.

Quotes need to be obtained from the individual vendors  
Remstar, 1-800-639-5805  
White 615-793-2558 (Gary Taylor)  
Kardex – 904-396-2731