NIOSH SHIPYARD ERGONOMICS PROJECT WORKSHOP

Hotel Monaco

New Orleans, Louisiana

November 15, 2002

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Original Workshop Agenda

0800 - 0815	Opening Remarks	Larry Reed
0815 - 0900	Shipyard Interventions I	Jim Albers
0900 - 1000	Shipyard Interventions II	Steve Hudock
1000 - 1015	Break	
1015 - 1100	Shipyard Trade Occupational Risk Matrix	Steve Hudock
1100 - 1130	Where Do We Go From Here?	Larry Reed
1130 - 1145	Closing Comments	Steve Hudock

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REVISED Workshop Agenda

0800 - 0815	Opening Remarks	Larry Reed
0815 - 0845	Project Background	Steve Hudock
0845 - 0915	Shipyard Interventions I	Jim Albers
0915 - 1000	Shipyard Interventions II	Matt Jaszkowiak
1000 - 1015	Break	
1015 - 1100	Other Interventions and the Shipyard Trade Occupational Risk Matrix	Steve Hudock
1100 - 1130	Where Do We Go From Here?	Larry Reed
1130 - 1145	Closing Comments	Steve Hudock

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Project Objective

Determine the effectiveness of ergonomic interventions for select maritime processes through reducing both the number and severity of injuries and lowering Workers' Compensation costs while improving quality and productivity.

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Project Background

- Early interest in shipyard ergonomics by NSRP SP-5 Committee, BIW ('95-96)
- Initial start as NIOSH project for FY98, 9/97
- Initial shipyard walkthrough visits (12 domestic and 5 in Japan), 5-12/98
- MARITECH ASE proposal submitted, 2/99

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Project Background (cont.)

- Proposal awarded: $304K + $283K cost share, 9/99
- Risk Factor Analysis shipyard visits (8 shipyards), 10/99 - 6/00
- Intervention follow-up visits (8 visits between 4 shipyards), 8/00 - 7/01

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Primary Participating Shipyards

- Bath Iron Works
- Continental Maritime
- Halter Marine Moss Point
- Ingalls
- Jeffboat
- Marinette Marine
- Puget Sound Naval Shipyard
- Todd Pacific

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Other Participating Shipyards

- Cascade General
- Electric Boat (Groton and Quonset Point)
- Halter Marine Pascagoula
- NASSCO
- Newport News Shipbuilding

- Ishikawajima-Harima Heavy Industries - Tokyo
- Sumitomo Heavy Industries - Yokosuka
- USN Ship Repair Facility - Yokuska
- Mitsui Engineering and Shipbuilding - Tamano
- Sanoyas Hishino Meisho - Mizushima
- Mitsubishi Heavy Industries - Nagasaki

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Steve Hudock

Quantification of Occupational Risk Factors

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Exposure Assessment Techniques

- NIOSH Lifting Equation
- Strain Index
- Rapid Upper Limb Assessment
- 3DSSPP
- Ovako Work Analysis System (posture)

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Work Processes Observed
-- Welding --

- Onboard Engine Room Wire Welding
- Tripod Subassembly Wire Welding in Shop
- Panel Line Wire Welding
- Onboard Deck Plate Welding
- Honeycomb Hull Welding

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Work Processes Observed
-- Subassembly --

- Onboard Lifeboat Rack Assembly
- Assembly Fitter Using Come-along in Shop
- Rakeframe Subassemblies in Shop
- Manhole and Hatch Assembly
- Onboard Reciprocating Saw Use

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Work Processes Observed
-- Sheetmetal --

- Onboard Duct Installation

- Sheetmetal Assembly in Shop

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Work Processes Observed
-- Deck Work --

- Onboard Deck Fitting
- Onboard Torch Cutting
- Onboard Deck Scraping
- Onboard Removal of Terrazzo Tile with Chipping Hammer

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Work Processes Observed
-- Blasting --

- Waterjet Blasting in Drydock

- Abrasive Blasting in Steelyard

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Work Processes Observed
-- Pipefitting --

- Onboard Pipe Welding Process (2)

- Shop Pipe Welding

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Work Processes Observed
-- Steelyard --

- Angle Iron Unload in Steelyard

- Angle Iron Positioning by Gator Bar

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Work Processes Observed
-- Insulation --

- Onboard Insulation Installation

- Onboard Insulation Removal

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Work Processes Observed
-- Shear --

- Shear Operation in Plate Shop (2)

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Work Processes Observed
-- MMH --

- Bin Loading by Material Handlers in Shop
- Bin Emptying and Sorting in Drydock
- Onboard Rigger Equipment Load-In
- Onboard Manual Material Handling

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Work Processes Observed
-- Grinding --

- Onboard Tank Grinding
- Onboard Grinding
- Panel Line Grinding

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Work Processes Observed
-- Electrical --

- Onboard Cable Connection

- Onboard Cable Pulling (2)

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Jim Albers

Todd Pacific and Marinette Marine Interventions

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Ergonomic Interventions at the Marinette Marine and Todd Shipyards

Jim Albers & Steve Hudock
Organizational Science & Human Factors Branch (OSHFB)
Division of Applied Research & Technology (DART)
National Institute for Occupational Safety & Health (NIOSH)

Purpose of Project

To evaluate recognized risk factors for work-related musculoskeletal disorders (WMSDs) and to provide effective ergonomic interventions to reduce risk

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Project Objectives

1. Identify shipyard tasks that expose workers to recognized risk factors for WRMDs
2. Perform a quantitative ergonomic analysis for each of the selected activities using exposure assessment tools
3. Recommend ergonomic interventions that are technologically and economically feasible
4. Determine the effectiveness of the ergonomic intervention and publicize the results

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Marinette & Todd Shipyards

- Marinette Marine
  - Marinette, WI
  - Build seagoing & long coastal buoy tenders and lodging barges
  - Built in 1942 & occupies 60 acres
  - 500,000 ft^2 enclosed workspaces
  - 650 employees
- Todd Pacific
  - Seattle, WA
  - Repair & overhaul commercial & military vessels
  - Built in 1916 & occupies 46 acres
  - 3 dry docks, 6000 ft. berthing space
  - 1,000 employees (~ 800 production workers)

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Jobs Evaluated at Marinette

- Engine room wire welding
- Tripod subassembly wire welding in shop
- Life boat rack assembly
- Sheet metal assembly in shop
- Assembly shipfitting in shop

[Hudock & Wurzelbacher, 2001a]

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NIOSH Job Evaluation

Engine room wire welding

- **Tasks:** Weld together and grind steel structure on vessel
- **Risk factors:** Prolonged awkward wrist & arm postures when welding. Prolonged knee bending (hyper-flexion) when squatting. Forward bending and neck flexion for work below knee height.

[Hudock & Wurzelbacher, 2001a]

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NIOSH Job Evaluation

Tripod subassembly wire welding

- **Tasks:** Weld and grind subassemblies in shop at fixed workstation
- **Risk factors:** Awkward and static wrist & arm postures and forward bending when welding. Prolonged knee bending (hyper-flexion) when squatting and kneeling. Hand-arm vibration when using needlegun.

[Hudock & Wurzelbacher, 2001a]

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NIOSH Job Evaluation

Life boat rack assembly

- **Tasks:** Torch cut & grind angle irons. Weld angle irons together on upper deck of vessel.
- **Risk factors:** Awkward and static wrist, arm and back postures. Prolonged knee bending (hyper-flexion) when squatting. Contact stress on knee when kneeling. Hand-arm vibration when using needlegun.
  [Hudock & Wurzelbacher, 2001a]

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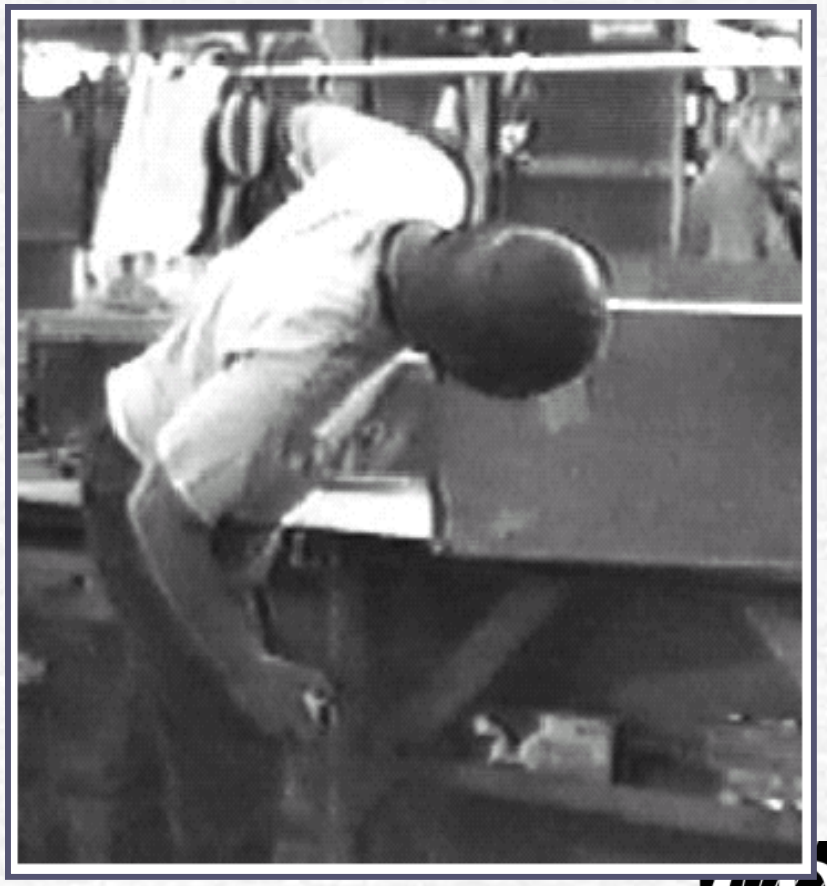
NIOSH Job Evaluation

Sheet metal assembly in shop

- **Tasks:** Form and fit (hammer) sheet metal together. Handle metal sheets and finished ducts, etc.

- **Risk factors:** Awkward wrist, arm and back postures.

[Hudock & Wurzelbacher, 2001a]



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NIOSH Job Evaluation

Assembly shipfitting in shop

- **Tasks:** Torch cut, grind and weld angle iron, steel plate and other materials into place so that subassemblies can be matched and secured

- **Risk factors:** Awkward & static postures. High physical forces fitting subassemblies. Handling materials and tools (come-along). Hand-arm vibration.

[Hudock & Wurzelbacher, 2001a]

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NIOSH Recommended Intervention

Engine room wire welding & life boat rack assembly

- Recommendation: Utilize industrial sit-stools, knee support, and knee pads to address knee hyper-flexion, forward bending, and contact stress on knees
- Outcome: All interventions not yet fully implemented. Shipyard working with knee pad provider on design concerns.

[Hudock & Wurzelbacher, 2001b]

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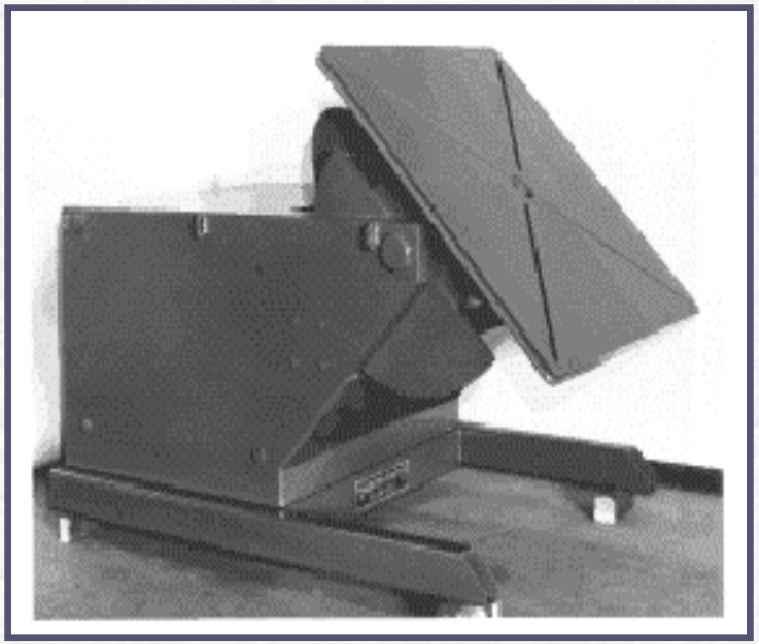
NIOSH Recommended Intervention

Tripod subassembly wire welding



- Recommendation: Use tilting, rotating and height adjustable weld positioner
  - eliminate need for sustained awkward postures
  - increase efficiency and quality
- Outcome: Intervention not yet implemented

[Hudock & Wurzelbacher, 2001b]

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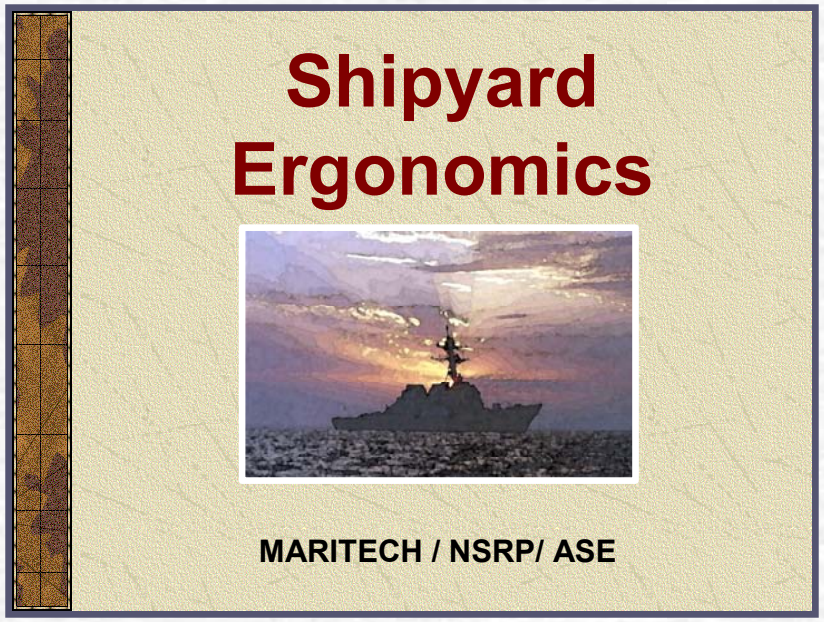
NIOSH Recommended Intervention

Sheet metal assembly in shop



- Recommendation: Provide ergonomic awareness training so workers will use available sheet metal equipment (e.g., bench-mount hand brakes, and metal forming presses), rather than hand tools
- Outcome: Ergonomic awareness training through Shipbuilders Council of America anticipated.

[Hudock & Wurzelbacher, 2001b]

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NIOSH Recommended Intervention

Assembly shipfitting in shop

- Recommendation: Provide high leverage puller to reduce physical force requirements
  - **Load capacity : Maximum pull**

    1500-1650 lbs : 45-68 lbs

    3000-3300 lbs : 55-73 lbs

    6000-6600 lbs : 62-77 lbs
  - Example: American Power Pull Model 144-D 2 Ton come-along with 36:1 leverage rating
- Outcome: Several new come-alongs purchased at shipyard

[Hudock & Wurzelbacher, 2001b]

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Jobs evaluated at Todd

- Pipe welding onboard vessel
- Torch cutting onboard vessel
- Water-jet blasting of vessel in dry-dock
- Grinding onboard vessel
- Semi-automatic wire welding onboard vessel

[Hudock & Wurzelbacher, 2001c]

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NIOSH Job Evaluation

Water-jet blasting of vessel

- Tasks: Manually hold water-jet during blasting while working on powered elevated platform
- Risk factors: High physical forces and awkward static postures, especially the hands, wrists, & elbows

[Hudock & Wurzelbacher, 2001c]

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NIOSH Job Evaluation

Pipe stick welding onboard vessel

- Tasks: Fit piping together, weld pipe, remove slag and grind weld in confined areas
- Risk factors: Static and awkward postures
  - hand-wrist flexion and ulnar & radial deviation
  - shoulder abduction
  - back flexion and extension

[Hudock & Wurzelbacher, 2001c]

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Torch cutting onboard vessel

- Tasks: Operate torch to cut steel onboard the vessel, e.g., decking, bulkhead while standing, kneeling or squatting

- Risk factors: Awkward and static postures of the knees, hips & torso and hand-wrist (welding). Contact stress (knees).

[Hudock & Wurzelbacher, 2001c]

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NIOSH Job Evaluation

Grinding onboard vessel

- Tasks: Grind paint and welding beads from horizontal and vertical surfaces on board vessel while standing, kneeling, or squatting
- Risk factors: Awkward and static postures of the knees, hips & torso, and hand-wrist. Contact stress (knees). Hand-arm vibration.

[Hudock & Wurzelbacher, 2001c]

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NIOSH Job Evaluation

Wire welding onboard vessel

- Tasks: Operate semi-automatic welder and wire welding onboard vessel. Remove slag from welds.
- Risk factors: Awkward and static postures of the knees and hips, hands-wrists, and shoulders. Contact stress (knees).
  [Hudock & Wurzelbacher, 2001c]

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NIOSH Recommended Intervention

Water-jet blasting of vessel

- Recommendation: Place a mount on the lift platform, e.g., railing, to hold and position water-jet
- Outcome:
  - Mount to hold and position water-jet placed on lift. Not used due to engineering concerns, e.g., load capacity of the lift.
  - NSRP funded project to investigate use of ultra high pressure water methods (NSRP, 2001).

[Hudock & Wurzelbacher, 2001d]

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NIOSH Recommended Intervention

Welding, torch cutting & grinding

Shipyard Ergonomics

MARITECH / NSRP/ ASE

- Recommendation: Ergonomic awareness training for production workers due to limited opportunities to modify workstations & implement engineering controls.
- Outcome: Three ergonomic awareness training sessions provided to Todd labor-management team and front-line supervisors during February 2001.

[Hudock & Wurzelbacher, 2001d]

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NIOSH Recommended Intervention

Welding, torch cutting & grinding

- Recommendation: Utilize industrial sit-stools, knee support, and knee pads to address knee hyper-flexion, forward bending, and contact stress on knees
- Outcome: Knee pads provided as PPE. Stools not yet implemented as intervention.

[Hudock & Wurzelbacher, 2001d]

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Shipyard initiated interventions

- Marinette Marine
  - Fabricated paint ‘pallets’ with open sides to prevent forward flexion when accessing 5 gallon containers and welded eyes on four corners of paint pallets to facilitate crane transport.

Shipyard initiated interventions

- Todd Pacific Shipyards
  - Japanese-style '5S' manufacturing program implemented in 18 installations, including the paint shop, tool room, bull maintenance, rigging shop, carpenters' shop and welding maintenance shop.
    - Training for key personnel included ergonomic principles, e.g., placing work at appropriate heights and distances, reducing manual material handling, and providing adequate illumination.
  - Active participant in NSRP "lean ship repair" program. Includes a mobilize, maintain, and demobilize (MMD) program which plans for the layout of temporary facilities which allows an orderly and systematic "pullback" of equipment following completion of the repair operations.

Conclusion

- Marinette Marine interventions:
  - Most interventions were not fully implemented. The wheeled, adjustable work stools were expected to provide a significant impact on reducing musculoskeletal injuries for workers in kneeling postures. The wheeled stools, however, were not widely accepted by employees.
- Todd Pacific
  - Several interventions were implemented. The ergonomic awareness training was expected to have significant impact on reducing musculoskeletal injuries for a ship repair facility. Future ergonomics training is anticipated for all employees through the SCA grant from OSHA.

References

- Hudock, S. D. and S. J. Wurzelbacher [2001a]. Preliminary Survey Report: Pre-Intervention Quantitative Risk Factor Analysis for Ship Repair Processes at Marinette Marine Corporation Shipyard, Marinette, Wisconsin. August 2001, Report No. EPHB 229-14a, NIOSH, Cincinnati, OH, 94 pp.
- Hudock, S. D. and S. J. Wurzelbacher [2001b]. Interim Survey Report: Recommendations for Ergonomic Interventions for Ship Repair Processes at Marinette Marine Corporation Shipyard, Marinette, Wisconsin. August 2001, Report No. EPHB 229-14b, NIOSH, Cincinnati, OH, 30 pp.
- Hudock, S. D. and S. J. Wurzelbacher [2001c]. Preliminary Survey Report: Pre-Intervention Quantitative Risk Factor Analysis for Ship Repair Processes at Todd Pacific Shipyards Corporation, Seattle, Washington. June 2000, Report No. EPHB 229-18a, NIOSH, Cincinnati, OH, 96 pp.
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- Hudock, S. D. [2002]. Interim Survey Report: Recommendations for Ergonomic Interventions for Ship Repair Processes at Todd Pacific Shipyards Corporation, Seattle, Washington. September 2002, Report No. EPHB 229-18c, NIOSH, Cincinnati, OH, 12 pp.
- Hudock, S. D. and J. T. Albers [2002]. Final Survey Report on Ergonomic Interventions for Ship Repair Processes at Marinette Marine Corporation Shipyard, Marinette, Wisconsin. October 2002, Report No. EPHB 229-14c, NIOSH, Cincinnati, OH, 9 pp.
- NSRP [2001] Ultra-High Pressure Water Blasting Project. National Shipbuilding Research Program, Maritech-ASE

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Matt Jaszkowiak

Puget Sound Naval Shipyard Intervention

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NIOSH Shipyard Ergonomics Project Workshop Puget Sound Intervention

Matthew N. Jaszkowiak
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Stephen D. Hudock, Ph.D.

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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Project Objectives

- Assessment of High Risk job.
- Reduced injury rates and lost workdays associated with scrap metal sorting operation.
- Reduced turnover associated with this task.

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History of Project

- Manual sorting of scrap metal from dismantling of ships
- Sorting task was chosen from several tasks identified by the shipyard.
- Tasks were identified based on their history of turnover and injury.

Pre-intervention Risk Factor Analysis

- University of Michigan 3DSSP
- Strain Index
- NIOSH Lifting Equation
- NIOSH Checklist for Manual Materials Handling
- OWAS
- University of Michigan Upper Extremity Cumulative Trauma Disorder checklist
- PLIBEL

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Worker Reaching to Bottom of Scrap Bin to Reach Object

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Worker Hanging Over Side of Scrap Bin on One Leg to Reach Object

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Worker Lifting Valve Assembly from Sorting Bin

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Development of Intervention

Collaboration between the Shipyard and a vendor

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Intervention in Operation

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Moving Scrap from Back of Bin

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Worker Lifting Scrap from Tilted Sorting Bin

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Quantitative Evaluation of Intervention

- Laboratory mock-up
- Peak motion capture with anatomical markers
- Task analysis using JACK® Human Modeling and Ergonomics Analysis software

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Pre-Intervention Laboratory Mock-up

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Post Intervention Laboratory Mock-up

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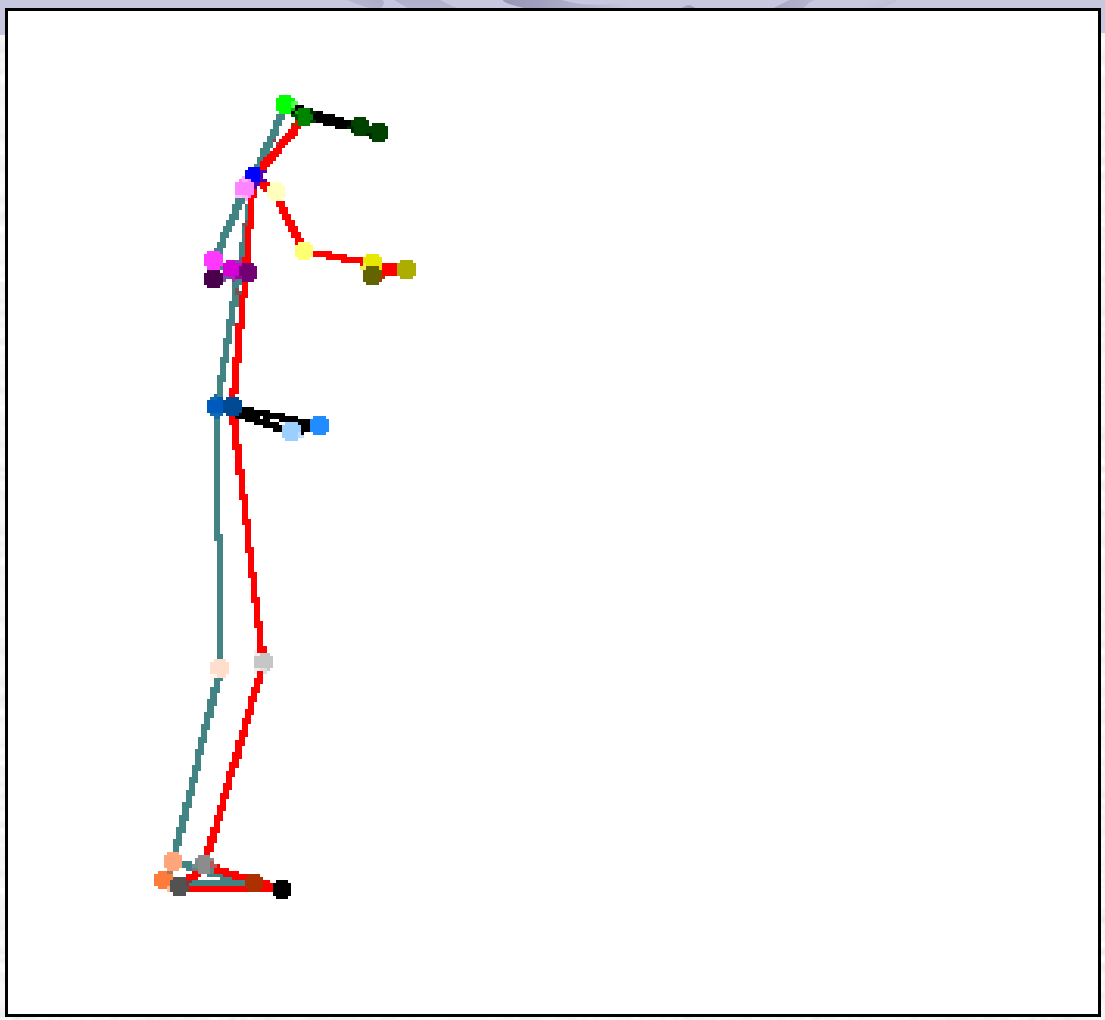

PEAK Motus Motion Capture Stick Figure with Markers

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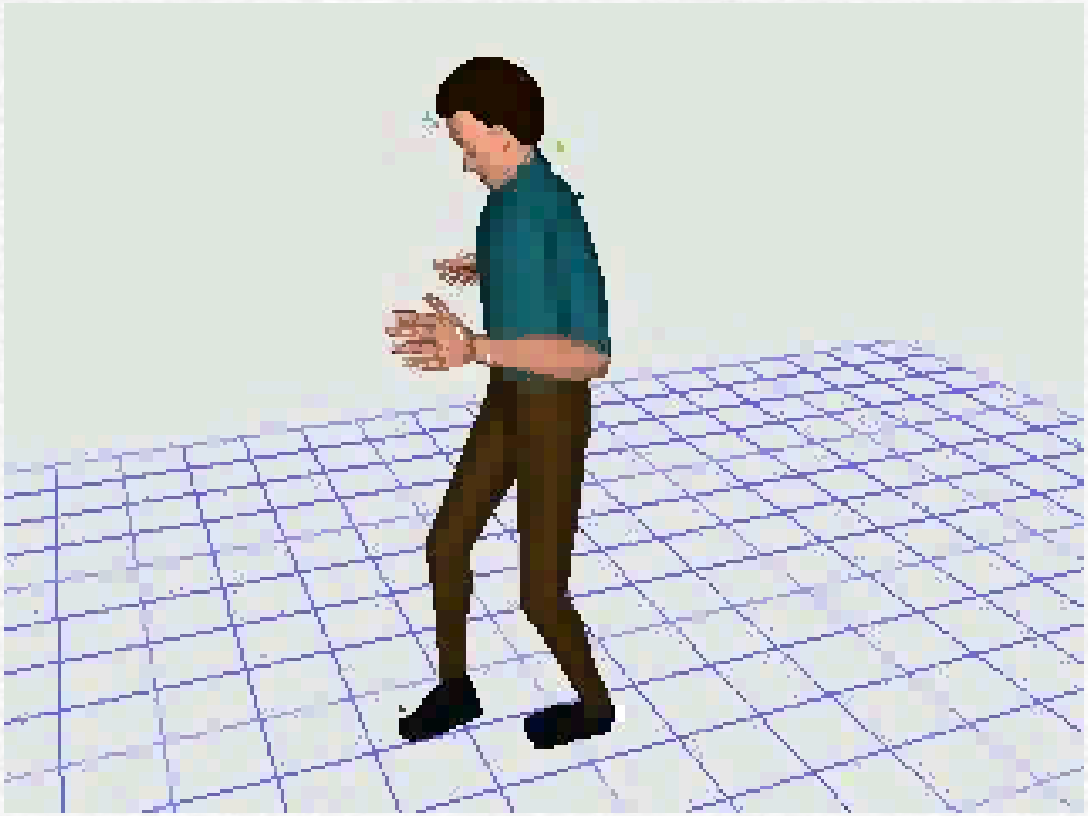

JACK Mannequin Animation

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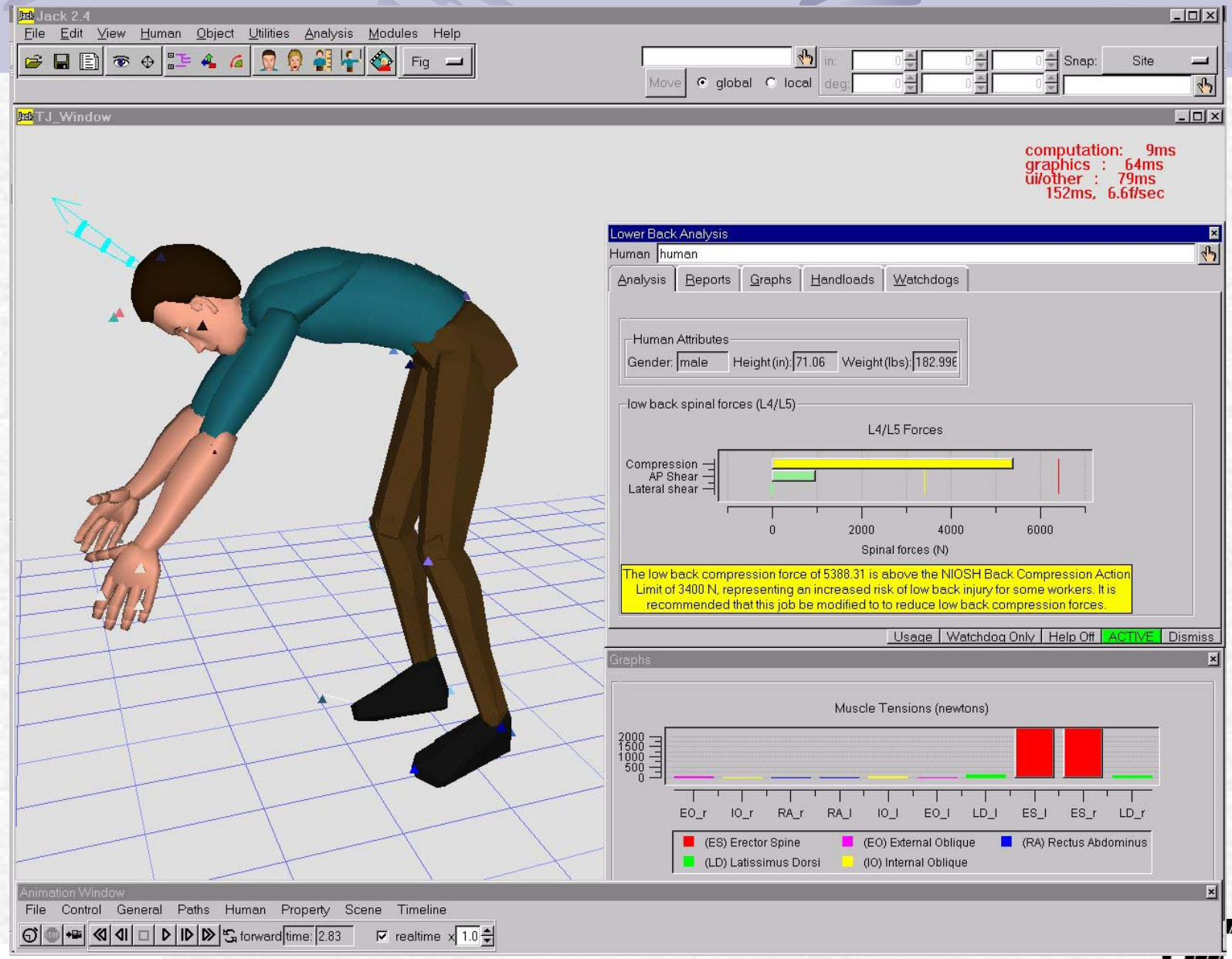

Lower Back Analysis – 50 lb lift near bottom of bin

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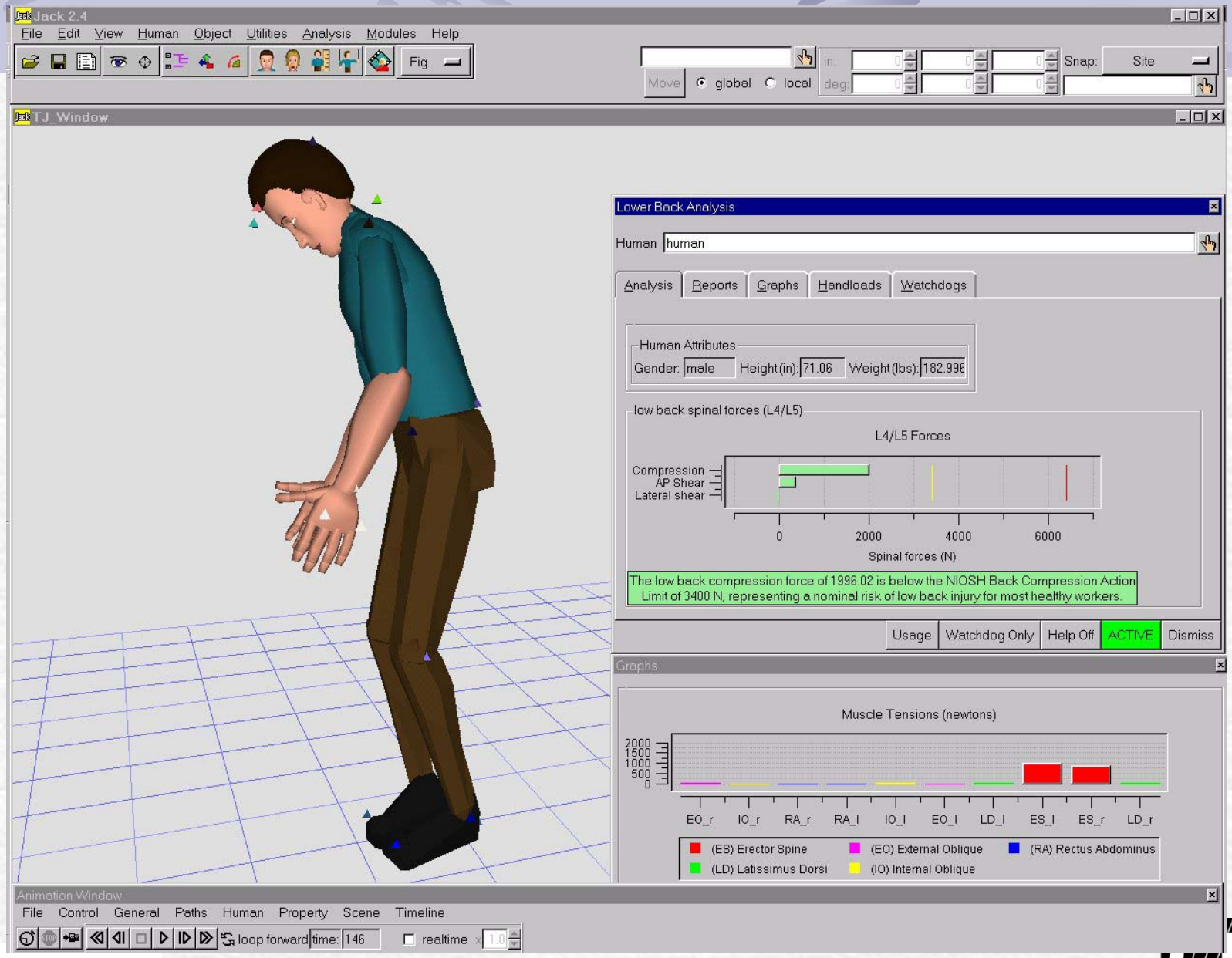

Lower Back Analysis Tool – 50 lb lift near front of bin

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Pre and Post Intervention Lower Back Analysis

Measure (30 kg hand load)	Pre-Intervention	Post-Intervention	Percent Reduction
L4 / L5 Disc Compression	7084 N	2922 N	59 %
Anterior / Posterior Shear	1234 N	511 N	59 %
Erector-Spinae Muscle Tension	3338 N	1362 N	59 %

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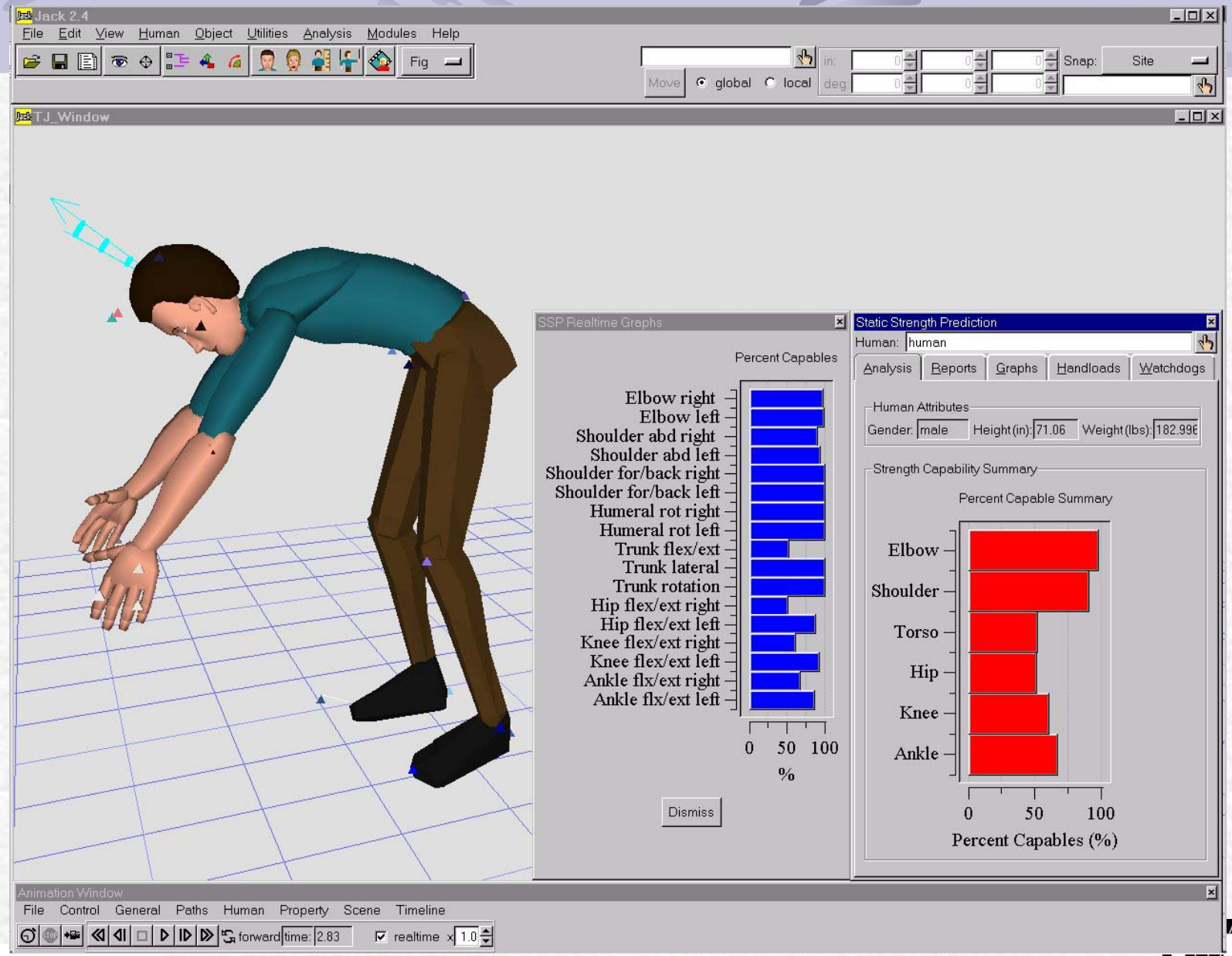

Static Strength Prediction – 50 lb lift near bottom of bin

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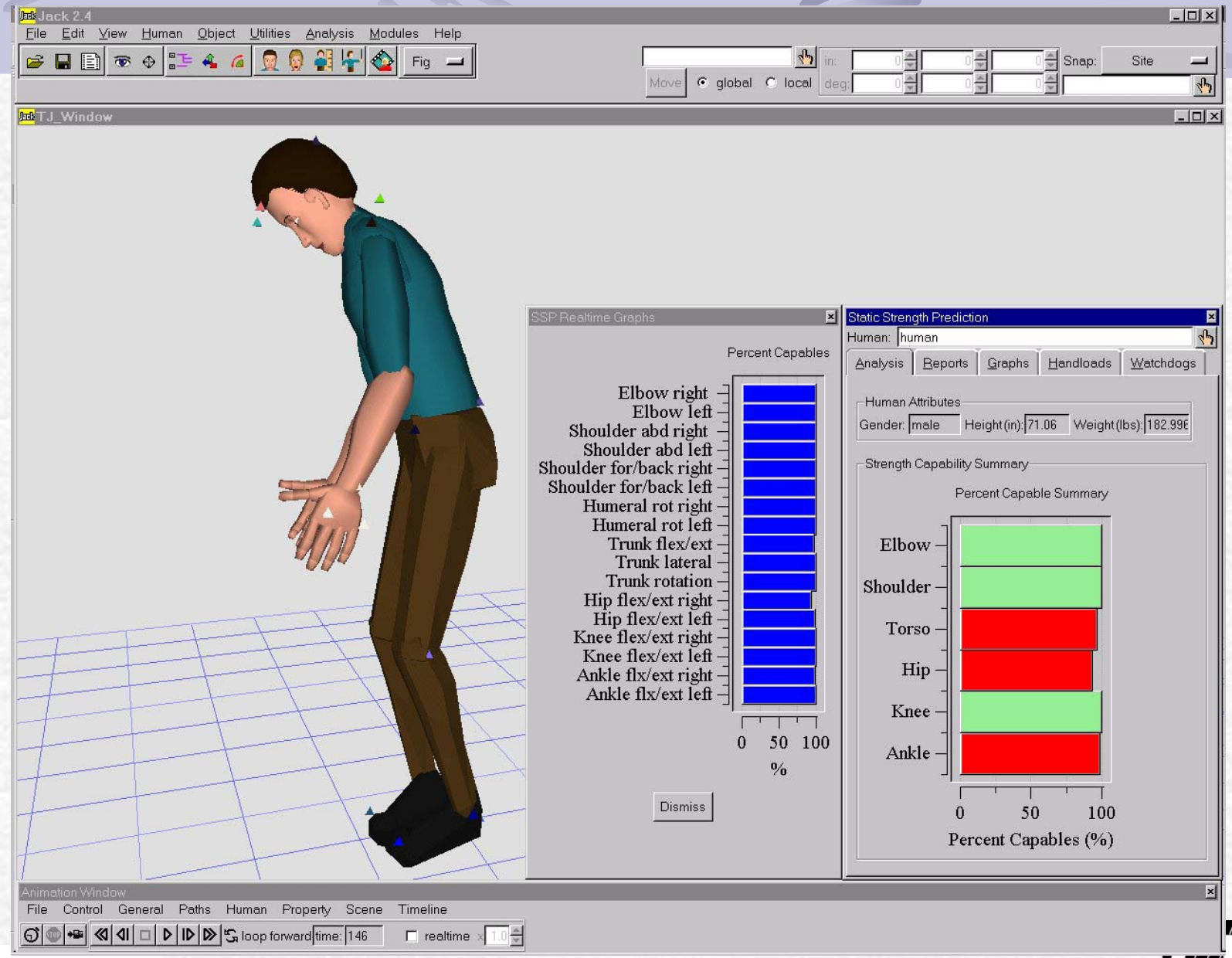

3D Static Strength Prediction – 50 lb lift near front of bin

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Michigan 3D Static Strength Prediction

Measure (Male % Capability 30kg load)	Pre-Intervention	Post-Intervention	Improvement
Torso	39 %	89 %	50 %
Hip	31 %	87 %	56 %
Shoulder	46 %	99 %	53 %

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NIOSH Lifting Equation

Measure	Pre-Intervention	Post-Intervention
Lifting Index 30 Kg load (LI)	5.46	1.93
Recommended Weight Limit (RWL)	5.50 Kg	16.08 Kg

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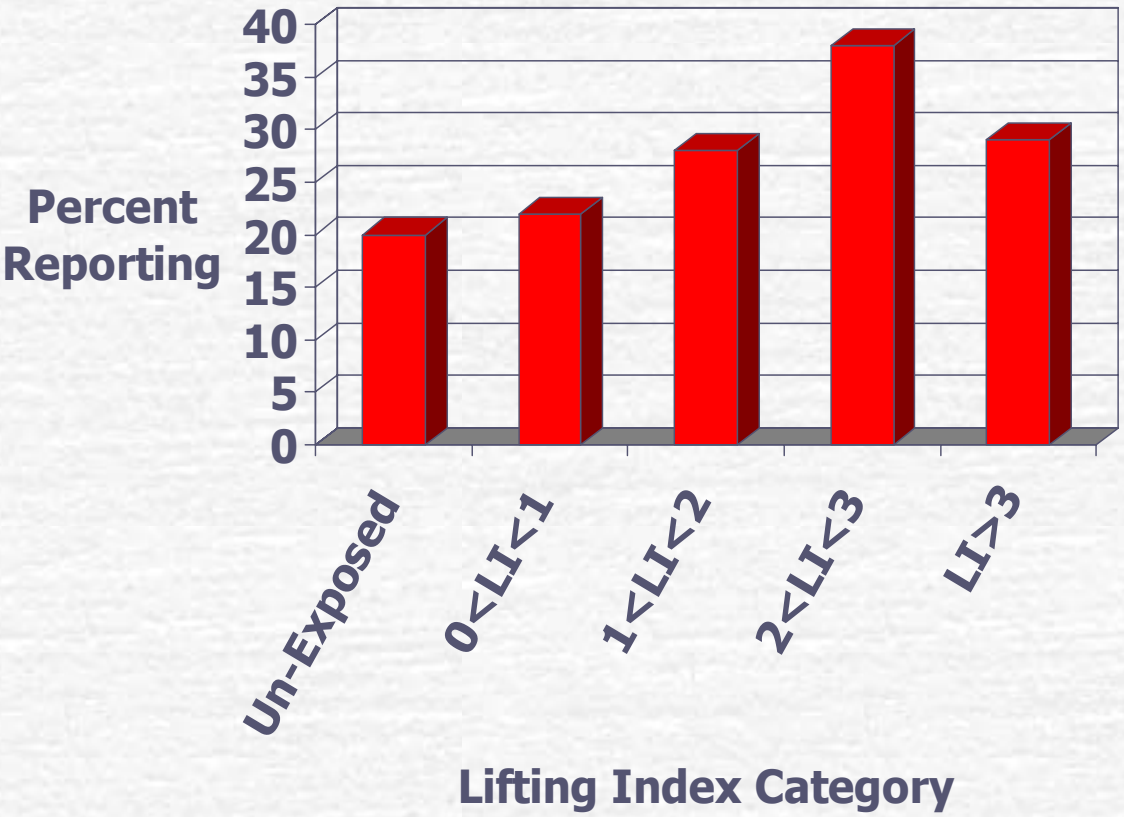
Low back pain prevalence by LI category

Waters et al., 1999



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Post-Intervention Evaluation

- Interview workers to determine effectiveness of intervention
- Follow-up with shipyard on injury rates and turnover associated with this task

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Steve Hudock

Other Ergonomic Interventions and STORM

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- Vibration Analysis of New vs. Used Pneumatic Tools
- Shear Lift Table at Jeffboat
- Cable Pulling System (U.S. Navy)
- Improved Welding Whip Trial (Ingalls)

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Shipyard Trade Occupational Risk Matrix (STORM)

Occupation by Risk Factor
Based on Incidence and Severity

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RISK FACTORS:

Body parts are listed under the risk factors that affect the parts for each trade.

(#) Shows how common and costly the body part injured by workers in each trade per year, with (1) being the most common.

Color Shows importance of risk factor for causing injuries in that trade. For example, red is most important, followed by orange, and then yellow. Green means that this is not a strong factor in causing muscle and joint injuries for that trade.

TRADE	Position held for a long time	Awkward positions	Repeated movement	Vibration	Too much force
Abrasive Blasters	(1) ARMS (2) SHOULDERS (3) BACK	(1) ARMS (2) SHOULDERS (3) BACK			(1) ARMS (2) SHOULDERS (3) BACK
Burners/ Torch Cutters	(1) KNEES (2) BACK (3) NECK (4) SHOULDERS (5) ARMS (6) HAND/ WRIST	(1) KNEES (2) BACK (3) NECK (4) SHOULDERS (5) ARMS (6) HAND/ WRIST			

TRADE	RISK FACTORS:				
	Position held for a long time	Awkward positions	Repeated movement	Vibration	Too much force
Electricians		(1) BACK (2) KNEES (3) HAND/ WRIST	(3) HAND/ WRIST (5) ARMS		(1) BACK (3) HAND/WRIST (4) SHOULDERS (5) ARMS
Grinders/ Chippers	(1) BACK (2) KNEES (3) ARMS (4) SHOULDERS (6) NECK	(1) BACK (2) KNEES (3) ARMS (4) SHOULDERS (5) HAND/ WRIST (6) NECK	(3) ARMS (4) SHOULDERS (5) HAND/ WRIST	(3) ARMS (4) SHOULDERS (5) HAND/ WRIST	(3) ARMS (4) SHOULDERS (5) HAND/ WRIST
Insulators		(1) HAND/ WRIST (2) SHOULDERS (3) NECK (4) BACK	(1) HAND/ WRIST (2) SHOULDERS		(1) HAND/ WRIST (2) SHOULDERS
Machinists	(1) BACK (2) NECK	(1) BACK (2) NECK			(1) BACK (3) SHOULDERS

TRADE	RISK FACTORS:				
	Position held for a long time	Awkward positions	Repeated movement	Vibration	Too much force
Material Handlers		(1) BACK (2) SHOULDERS (3) ARMS	(1) BACK (2) SHOULDERS (3) ARMS		(1) BACK (2) SHOULDERS (3) ARMS
Outfitters		(1) BACK (2) ANKLES (3) KNEES (4) HAND/ WRIST			(1) BACK (4) HAND/ WRIST
Pipefitters		(1) BACK (2) KNEES (3) ARMS (4) NECK	(3) ARMS (5) HAND/ WRIST		(1) BACK (3) ARMS (5) HAND/ WRIST
Riggers		(1) SHOULDERS (2) BACK (3) KNEES			(1) SHOULDERS (2) BACK

TRADE	RISK FACTORS:				
	Position held for a long time	Awkward positions	Repeated movement	Vibration	Too much force
Saw Operators		(1) HAND/ WRIST (2) ARMS (3) SHOULDERS (4) BACK		(1) HAND/ WRIST (2) ARMS (3) SHOULDERS	(1) HAND/ WRIST (2) ARMS (3) SHOULDERS (4) BACK
Sheetmetal		(1) BACK (2) NECK (3) KNEES	(4) ARMS (5) HAND/ WRIST		(4) ARMS (5) HAND/ WRIST
Shipfitters		(1) BACK (2) KNEES (3) NECK (4) HAND/ WRIST (5) ARMS (6) SHOULDERS	(1) BACK (4) HAND/ WRIST (5) ARMS (6) SHOULDERS		(1) BACK (4) HAND/ WRIST (5) ARMS (6) SHOULDERS
Welders	(1) KNEES (2) BACK (3) NECK (4) SHOULDERS (5) ARMS (6) HAND/ WRIST	(1) KNEES (2) BACK (3) NECK (4) SHOULDERS (5) ARMS (6) HAND/ WRIST			(2) BACK (6) HAND/ WRIST

Where do we go from here?

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Compendium Document

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Workshops

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Voluntary Industry Guidelines

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Information Dissemination and Closing Remarks

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INFORMATION DISSEMINATION

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CONFERENCE PRESENTATIONS

1. International Occupational Hygiene Association 5th International Scientific Conference, Bergen, Norway, June 2002. Recognition, Evaluation and Control of Ergonomic Hazards in the Shipyard Industries. S. D. Hudock.

2. 5th Annual Applied Ergonomics Conference, Baltimore, Maryland, March 2002. Ergonomic Intervention for a Scrap Metal Sorting Operation. M. N. Jaszkowiak, D. M. Werren, S. D. Hudock.

3. 5th Annual Applied Ergonomics Conference, Baltimore, Maryland, March 2002. Ergonomic Interventions for the Manufacture and Repair of Ships. S. D. Hudock.

4. PREMUS 2001 – 4th International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders, Amsterdam, The Netherlands, October 2001. Lower Extremity Musculoskeletal Disorders in the Shipbuilding and Ship Repair Industries. Poster. S. D. Hudock, S. J. Wurzelbacher, T. R. Hales and K. V. Siegfried.

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CONFERENCE PRESENTATIONS (cont.)

5. American Industrial Hygiene Conference and Exposition, New Orleans, Louisiana. The Effect of Two Ventilation Methods on Weld Fume Exposure in a Shipyard Confined-Space Welding Task. S. Wurzelbacher, O. Johnston, S. Hudock, L. Blade and S. Shulman.

6. 2nd International Congress on Maritime Technological Innovations and Research, Cadiz, Spain, November 2002. Ergonomic Interventions and Innovations for theMaritime Industries. S. D. Hudock, S. J. Wurzelbacher, L. D. Reed, and K. V. Siegfried.

7. International Ergonomics Association 2000/Human Factors and Ergonomics Society 2000, San Diego, California, July 2000. Electromyographic and Discomfort Analysis of a Confined-Space Welding Task. Poster. B. D. Lowe, S. J. Wurzelbacher and S. D. Hudock.

8. American Industrial Hygiene Conference and Exposition, Orlando, Florida, May 2000. Shipyard Confined Space Welding Intervention. S. J. Wurzelbacher, S. D. Hudock, B. D. Lowe, O. E. Johnston and S. A. Shulman.

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CONFERENCE PRESENTATIONS (cont.)

9. American Industrial Hygiene Conference and Exposition, Toronto, Ontario, Canada, June 1999. Anthology of Shipyard Ergonomic Solutions. S. D. Hudock, J. D. McGlothlin, L. D. Reed, T. R. Hales, S. J. Wurzelbacher and K. V. Siegfried.

10. American Industrial Hygiene Conference and Exposition, Toronto, Ontario, Canada, June 1999. Using Ergonomic Interventions as a Matrix to Compare Japanese and American Shipbuilding and Repair Industries. J. D. McGlothlin, S. D. Hudock, T. R. Hales, L. D. Reed, S. J. Wurzelbacher and K. V. Siegfried.

11. Institute of Industrial Engineers Solutions '99 Conference, Phoenix, Arizona, May 1999. Comparison of Work Methods, Productivity and Safety Between U.S. and Japanese Shipyards. S. D. Hudock and K. V. Siegfried.

12. Second Applied Ergonomics Conference, Houston, Texas, March 1999. Ergonomic Interventions for the Domestic Shipbuilding and Ship Repair Industry. S. D. Hudock and K. V. Siegfried.

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COMMITTEE MEETINGS

MACOSH, Baltimore, Maryland, December 2000.
MACOSH, King's Point, New York, July 2000.
MACOSH, Houston, Texas, March 2000.
MACOSH, Annapolis, Maryland, November 1999.
MACOSH, San Francisco, California, June 1999.
MACOSH, New Orleans, Louisiana, January 1999.
NSRP SP-5, New Orleans, Louisiana, November 1998.
NSRP SP-5, Washington, DC, August 1998.
NSRP SP-5, Seattle, Washington, June 1998.

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JOURNAL ARTICLES

1. Wurzelbacher, S. J., S. D. Hudock, O. E. Johnston, L. M. Blade and S. A. Shulman. A Pilot Study on the Effects of Two Ventilation Methods on Weld Fume Exposure in a Shipyard Confined Space Welding Task. *Applied Occupational and Environmental Hygiene*, 17(11):735-740, November 2002.

2. Wasserman, D. E., S. D. Hudock, J. F. Wasserman, L. Mullinix, S. J. Wurzelbacher and K. V. Siegfried. Hand-Arm Vibration in a Group of Hand-Operated Grinding Tools. *Human Factors and Ergonomics in Manufacturing*, 12(2):211-226, March 2002.

3. Hudock, S. D., S. J. Wurzelbacher, L. D. Reed, T. R. Hales and K. V. Siegfried. A Precursor of Ergonomics Best Practices for the Shipyard Industries. *Journal of Ship Production*, The Society of Naval Architects and Marine Engineers, Jersey City, NJ, 17(3):145-150, August 2001.

4. Lowe, B. D., S. J. Wurzelbacher, S. A. Shulman and S. D. Hudock. Electromyographic and Discomfort Analysis of Confined-Space Shipyard Welding Processes. *Applied Ergonomics*, 32(3):255-269, June 2001.

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TECHNICAL REPORTS

- 8 Preliminary Reports: Pre-Intervention Quantitative Risk Factor Analyses
- 8 Interim Reports: Suggested Ergonomic Interventions
- 1999, 2000 OSHA 200 Log Injury/Illness Incidence Reports
- above reports available at www.cdc.gov/niosh/ergship/reports.html

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- 8 Final Reports: Actions Taken (under review by shipyards)
- Compilation Report (under preparation)

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WEBSITE

Ergonomic Interventions in the Building, Repair, and Dismantling of Ships

at www.cdc.gov/niosh/ergship/ergship.html

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