MARITIME FALL PROTECTION ISSUES

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MARITIME FALL PROTECTION ISSUES

Purposes:

- Discuss current issues and needs

- Engage cooperative efforts of those in diverse industries and settings to share information and approaches

MARITIME FALL PROTECTION ISSUES

a. Identify common issues

b. Review statistics

c. Hazards in existing situation

d. Potential approaches to new designs

MARITIME FALL PROTECTION ISSUES

f. Identify areas of inefficiency (often consistent with increased safety risk)

g. Suggest management approach to review of risks (time, cost, performance, life-cycle costs, human risks)

h. Identify areas of future need and focus

Identify issues

Statistics

Existing design

New design

Management

Future needs & focus

Construction of the Ronald Reagan CVN 76

http://www.Reagan.navy.mil/

http://www.osha.gov/SLTC/etools/shipyard/shiprepair/

http://www.osha.gov/SLTC/etools/shipyard/shiprepair/

Identify issues

Statistics

Existing design

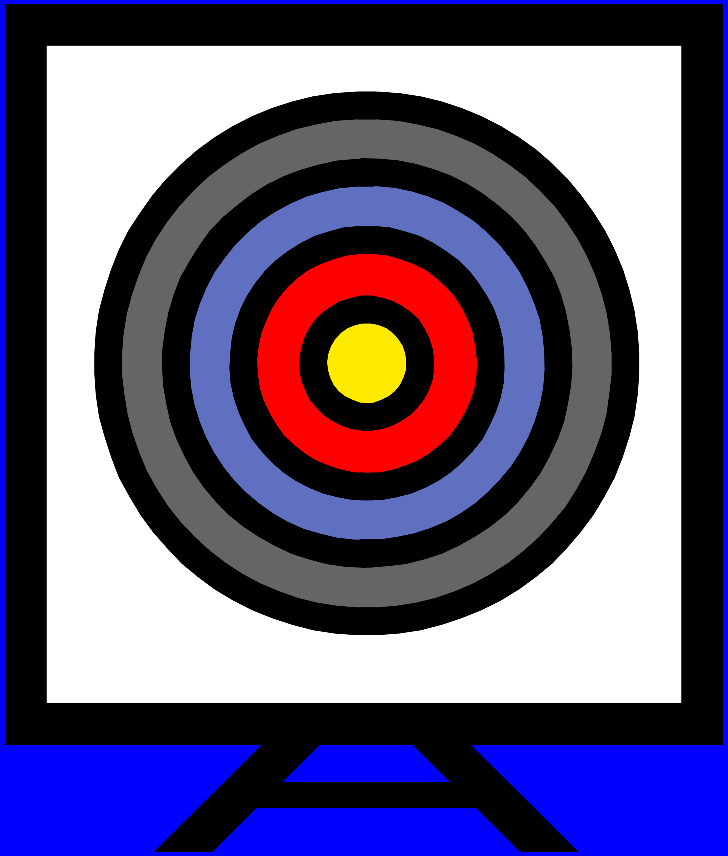
New design

Management

Future needs & focus

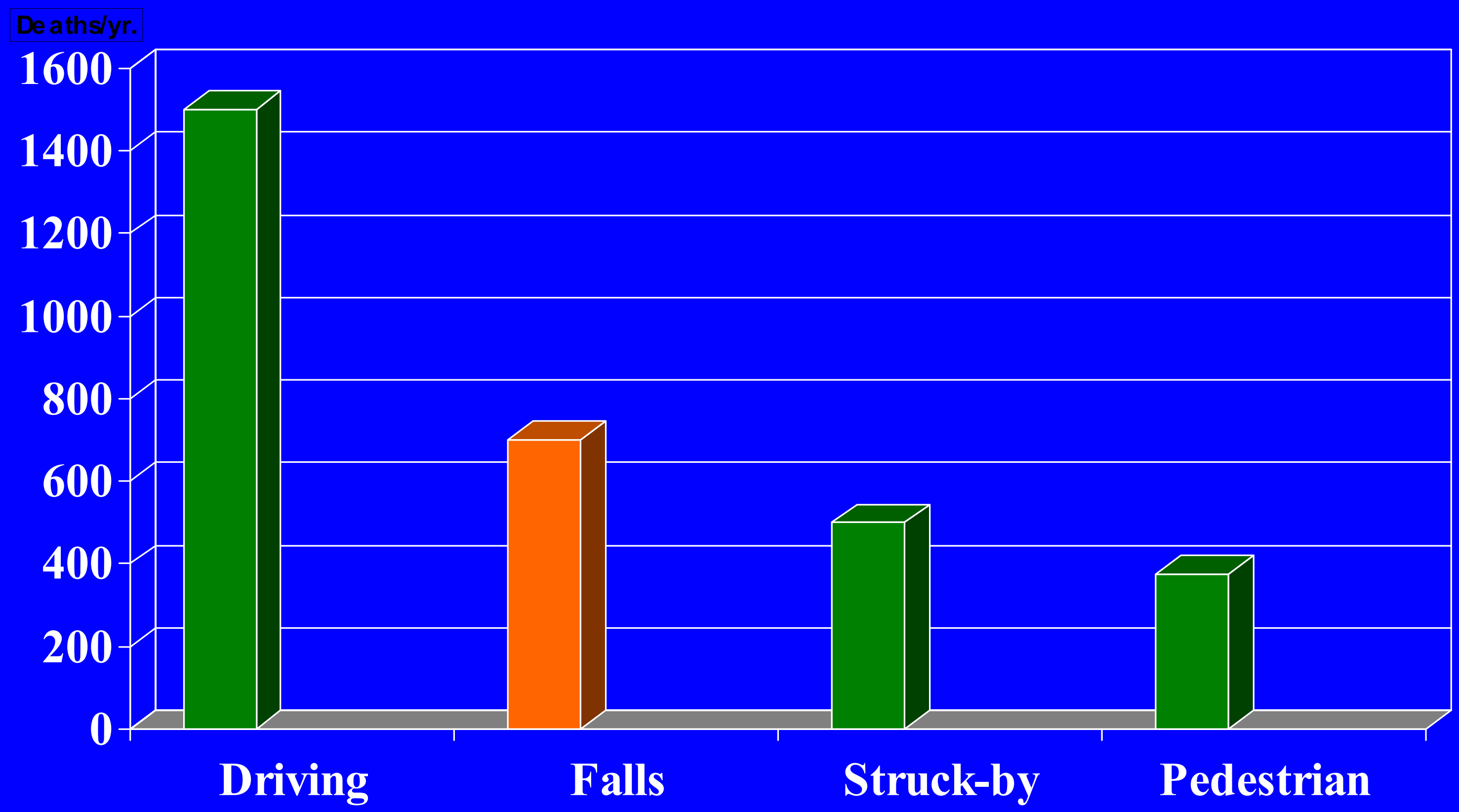
STATISTICS AND TARGETING KEY ISSUES

- Shipyard activity as America's second most hazardous industry.
- Falls injuries; personnel living on and repairing large vessels



HOW WORKERS DIE AT WORK

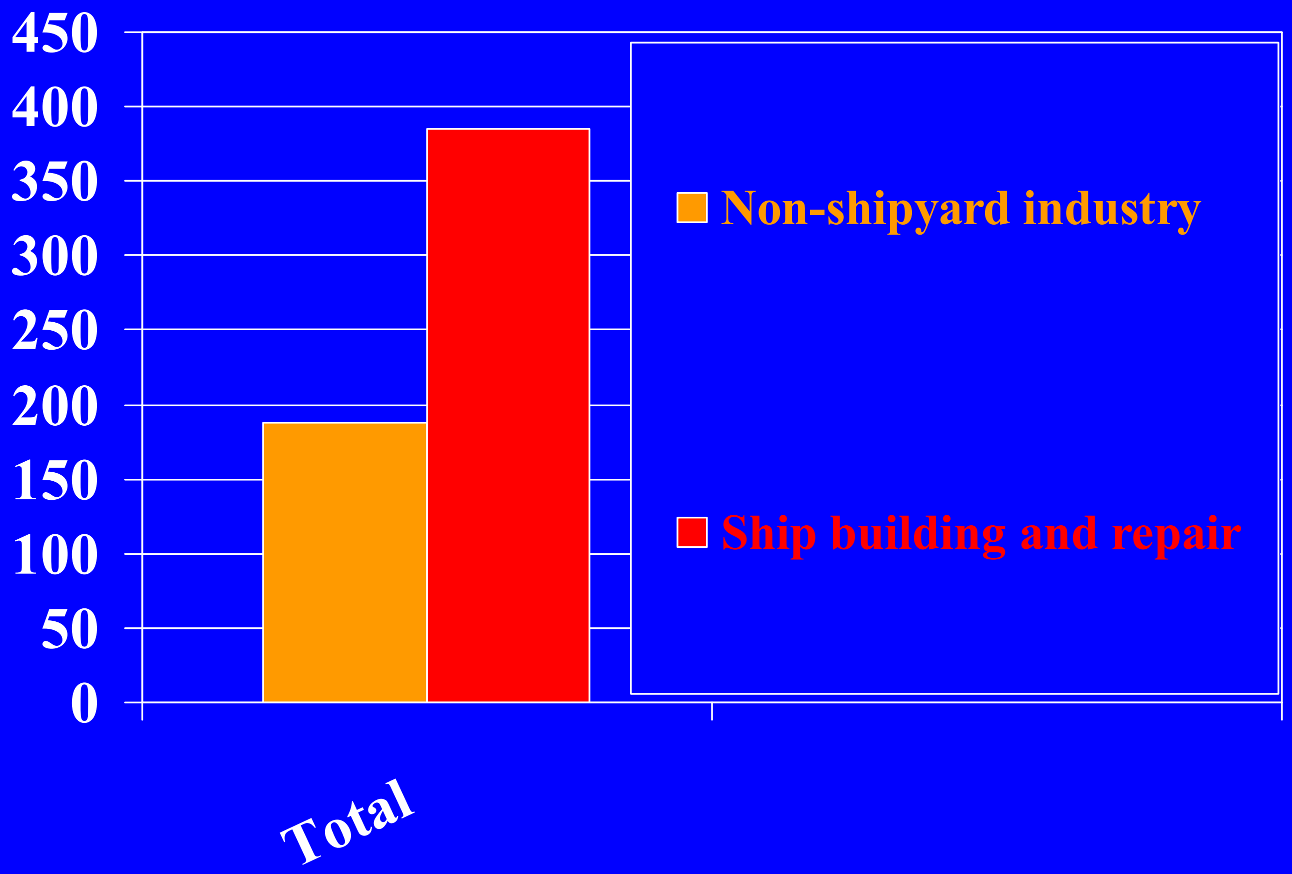
1999 BLS Data on number of accidental deaths occurring by event that year (nationally)



Falls represent 4th leading cause of accidental deaths in US
(occupational and non-work related)

NON-FATAL OCCUPATIONAL ILLNESS AND INJURY RATES FOR 1999

Rates adjusted per 100,000 man-hours



SHIPYARD FALL INJURIES

United Kingdom Health and Safety Executive Data 2001/2002

http://www.hse.gov.uk/aboutus/meetings/ships/

- Falls from height account for 23% of major injuries in shipyards

- Slips, trips, and falls to same level account for 25% of major injuries in shipyards

  - Major injury defined as $\geq$ 3 lost days

SUMMARY OF FALLS IN A MAJOR SHIPYARD

Type of fall occurrences:

• Falls at same level (slip-trip-fall)	54%
• Fall through opening or other space	24%
• Fall from ladder or scaffold	19%
• Fall between different levels	16%
• Falls on stairs/steps	9%

Identify issues

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NSRP Fall Best Practices for Slips, Trips and Falls Prevention

Summary information only

Report distribution limited to US Shipyards, NAVSEA and sponsors

National Shipbuilding Research Program 873-760-3366

NSRP* FALL BEST PRACTICES FOR SLIPS, TRIPS AND FALLS PREVENTION

- Summary information only

- Participants 8 shipyards representing about ½ US workforce
- 20 % total injuries
- 30% of lost time injuries

- National Shipbuilding Research Program 873-760-3366

FALL ACCIDENT TYPES CONSIDERED

NSRP Fall Best Practices for Slips, Trips and Falls Prevention

- Tripping or stumbling over obstructions
- Slipping due to slippery surfaces
- On or from stairs
- On or from ladders
- From buildings, structures or equipment
- Into holes or open surfaces
- On or from scaffolds
- From bicycles
- Other

Shipyard Fall Accidents

Accident type	Average lost days
Scaffolds	50
Bicycles	43
Into holes or open surface	37
Tripping or stumbling over obstructions	33
Stairs	28
Ladders	22
From buildings or structures	22
Slipping due to slippery surfaces	21
Other	20
Average	28
Areas mostly likely to be influenced by design	

Statistics

Identify issues

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AREAS OF CONCERN

- **Deep tanks and voids ***
- **Inclined ladders ("stairs") ***
- **Vertical ladders**
- **Masts and vertical passageways**
- **Deck or other edge protection**
- **Working over the side.**

* Focus of presentation

TRIPPING OR STUMBLING OVER OBSTRUCTIONS

Shipyard Fall Accidents

Key factors and prevention
Housekeeping
Contrast – marking of different surfaces*
Organization & planning of work process*
Training – limit carrying loads that hinder visibility
Protruding objects – mark and cover*
* Amenable to engineering controls

SHIPYARD FALL HAZARDS – SLIPS TRIPS AND FALL – SAME LEVEL

NIOSH Ergonomic solutions for shipyards
http://www.cdc.gov/niosh/ergship/building.html

- Hazard: Haphazard storage or placement of electrical cable or hoses tripping hazards to the workers.

  Solution: Orderly storage ensures availability of the part and eliminates a tripping hazard.

TRIPPING OR STUMBLING DUE TO SLIPPERY CONDITIONS

Shipyard Fall Accidents

Key factors and prevention
Housekeeping
Inspection and maintenance*
Organization & planning of work process*
Isolate or cover slippery areas*
Improve traction (non-skid surfaces and shoes)*
Welding sticks (keep in container)
Surface conditions – snow & ice removal
* Amenable to engineering and administrative controls

FALLS FROM BICYCLES

Average lost time 43 days

Key factors and prevention Most amendable to managerial and engineering controls
-Sudden equipment failure - inspection before use -Improper location –training (and housekeeping) -Baskets adequate for materials handling -Three wheels for increased stability when transporting materials -Reflectors to improve visibility -Training

FALLS FROM STAIRS

(Likely to also include some falls from ship inclined ladders)

Shipyard Fall Accidents

Key factors and prevention
Inspection and maintenance
Improve traction (non-skid surfaces and shoes)
Surface conditions – snow & ice removal
Training -carrying bulky materials (also relates to design and management for materials handling)
Lighting
* Amenable to engineering and administrative controls

FALLS FROM STAIRS (2)

(Likely to also include some falls from ship inclined ladders)

Key factors and prevention
Uneven surfaces (especially first stair)*
Traction (non-skid surfaces)*
Training -carrying bulky materials (also relates to design and management for materials handling)*
Lighting*
Ladder angle* (especially ship inclined ladders)
* Amenable to engineering controls

SMALL ELEVATOR AS ALTERNATIVE TO STAIRS

http://www.cdc.gov/niosh/ergship/elevator.html

Hazard: Normally access to top of ship at the dock for both personnel and some material is by series of stairs placed alongside. The stairs can be physiologically stressful especially when carrying items in hand (see photos).
Solution: A small elevator installed alongside the ship allows for easy transport of personnel and material

APPROACHES TO IMPROVE SHIPBOARD INCLINED LADDER "STAIR" DESIGN

- Improve general design for material handling in all areas –
  - Reduce the need to carry equipment on ladders
- Use existing specifications and design guidelines for ladder angle.
- Provide stabile and robust handrail at top of ladder

FALLS FROM LADDERS

(Likely to include some falls from ship inclined ladders)

Key factors and prevention- all influenced by design
Design – use stairs versus ladders when feasible Design- pitch of ship inclined ladders should be $\leq 50^{o}$ (now typically 65-75^{o}) Design – use of ladder rails that can be extended through hatch opening (and compressed during hatch closure) NEW DESIGNS Design and construction (use of durable materials) Interference – other lines run down ladder well. Plan for alternative passways

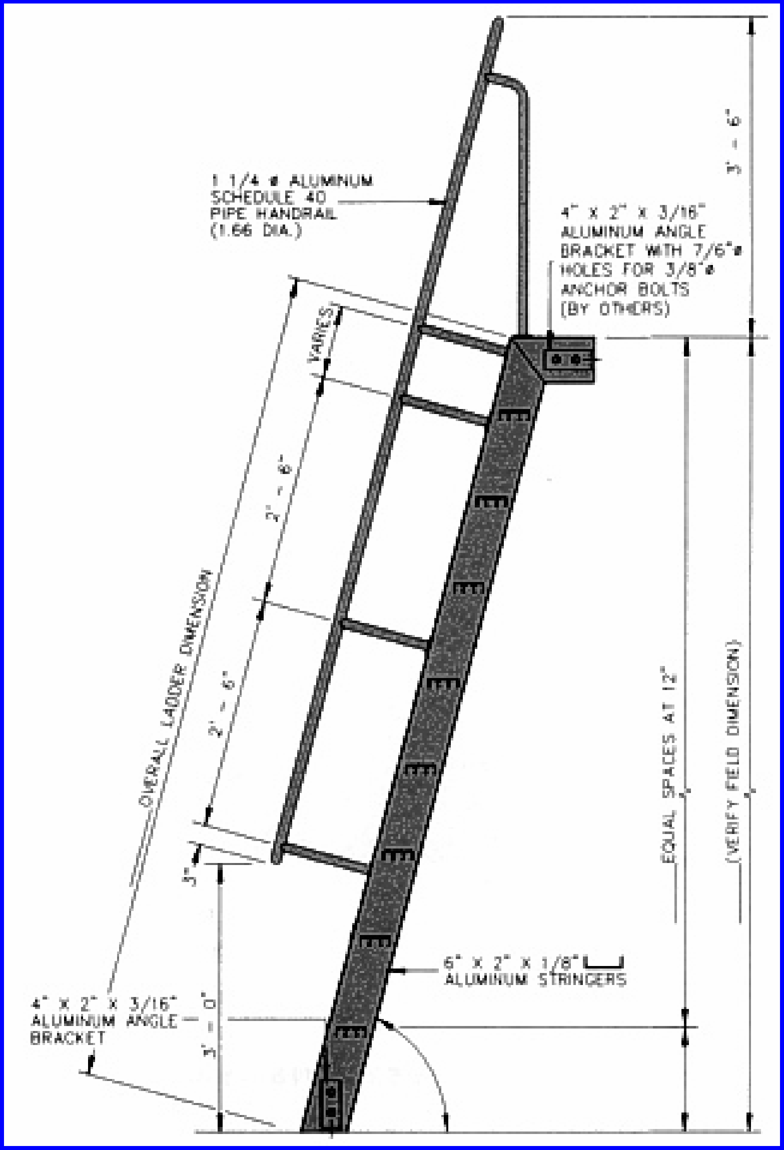
NIOSH ERGONOMIC GUIDES FOR SHIPYARDS

http://www.cdc.gov/niosh/ergship/scissman.html

Risk of Falls from Ladders?

<u>Consider manlift as alternative</u>

COMMON DESIGN FOR SHIP LADDERS

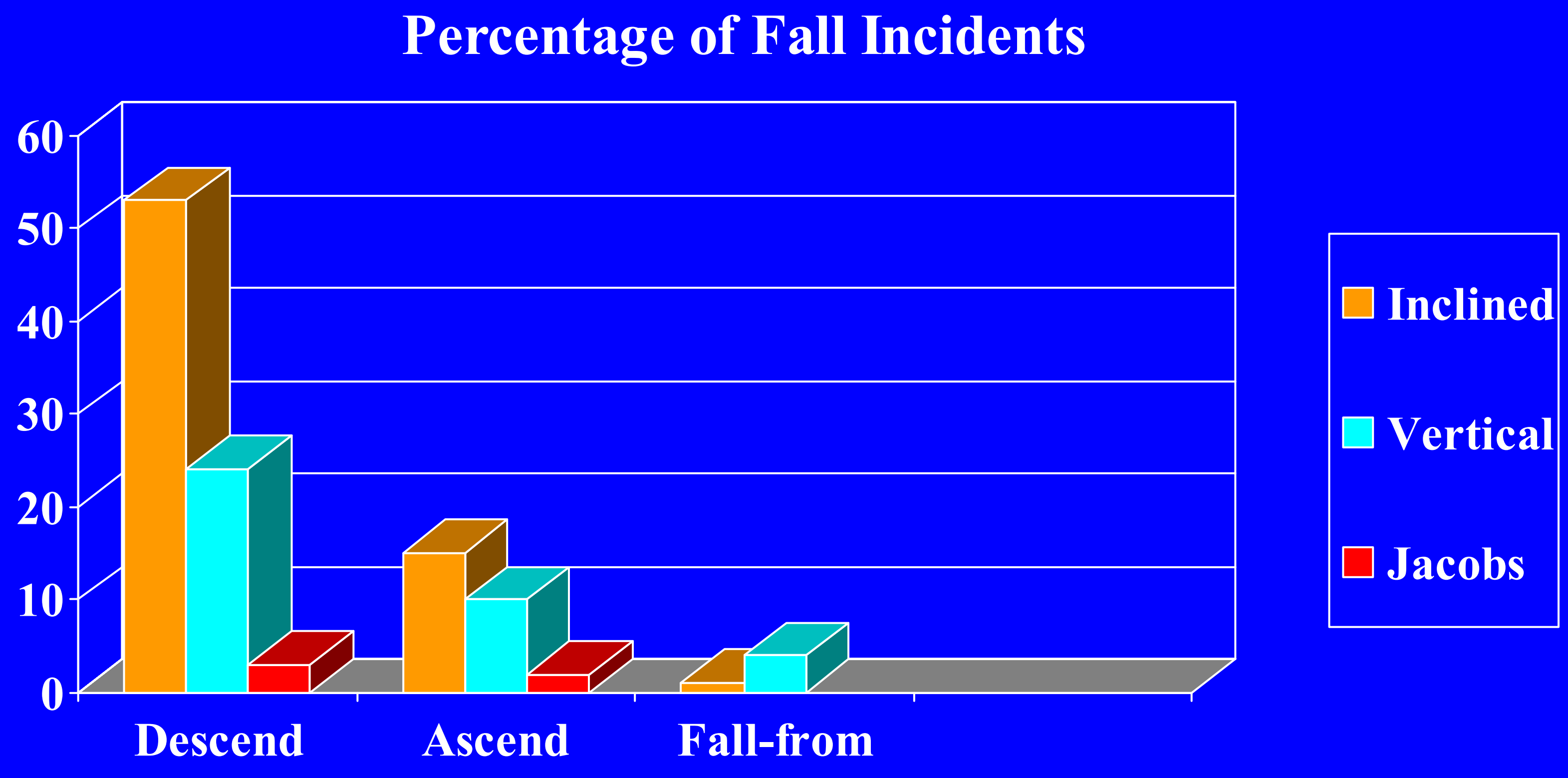


- **SHIPS LADDER 68º STEEP INCLINE**

ABS Suggests 38º for stairs, 50-60º for inclined ladders

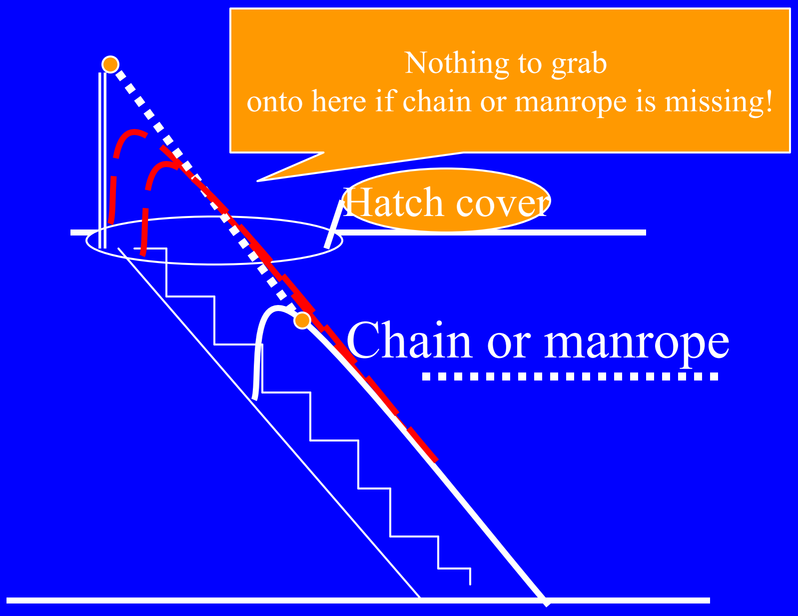
FALL DATA INVOLVING AIRCRAFT CARRIER (CVN) BY LADDER TYPE

Naval Safety Center analysis of 203 incidents over 10 years



LACK OF UPPER RAILING ON INCLINED LADDERS BETWEEN DECKS

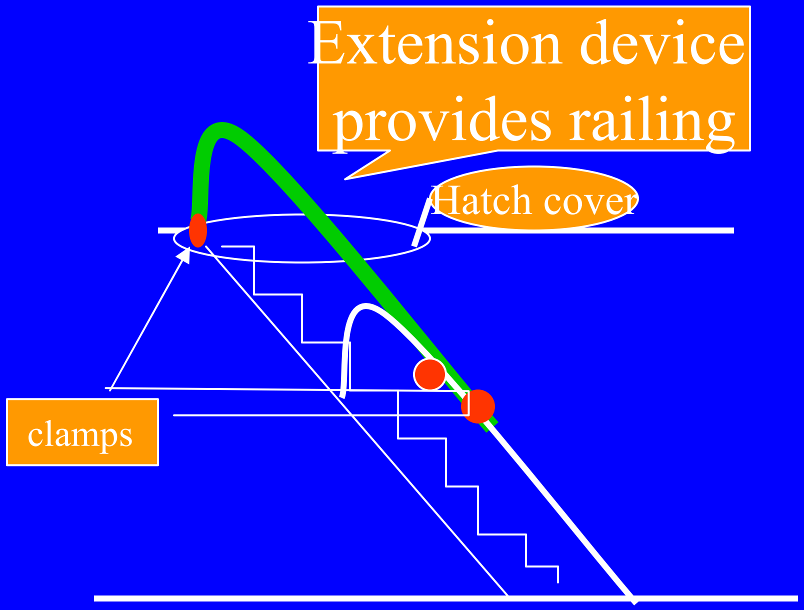
- Nothing for the occupant to grab onto and slow down on the approach to descending an inclined ladder.
- Hatch opening is may not be fully protected.
- Many falls on the first (top) four steps.
- **Many falls have occurred while occupant is carrying something.**



THE INTRA-DECK EXTENSION DEVICE

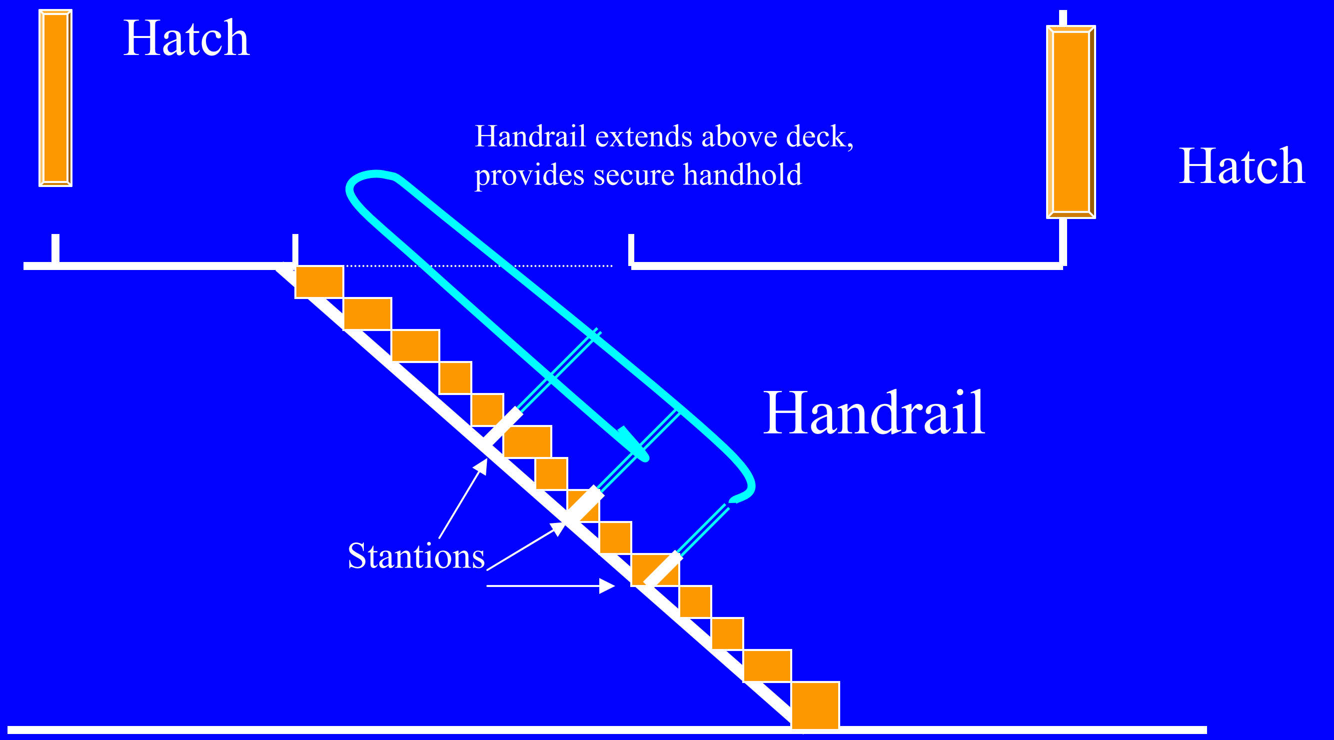
Developed by James Scull, Newport News

- Allows for the occupant to grab onto and slow down on the approach to descending an inclined ladder.
- Protects the opening.
- Extension detaches for allowing positive intra-deck hatch closure.
- Remaining limitation- use at sea.



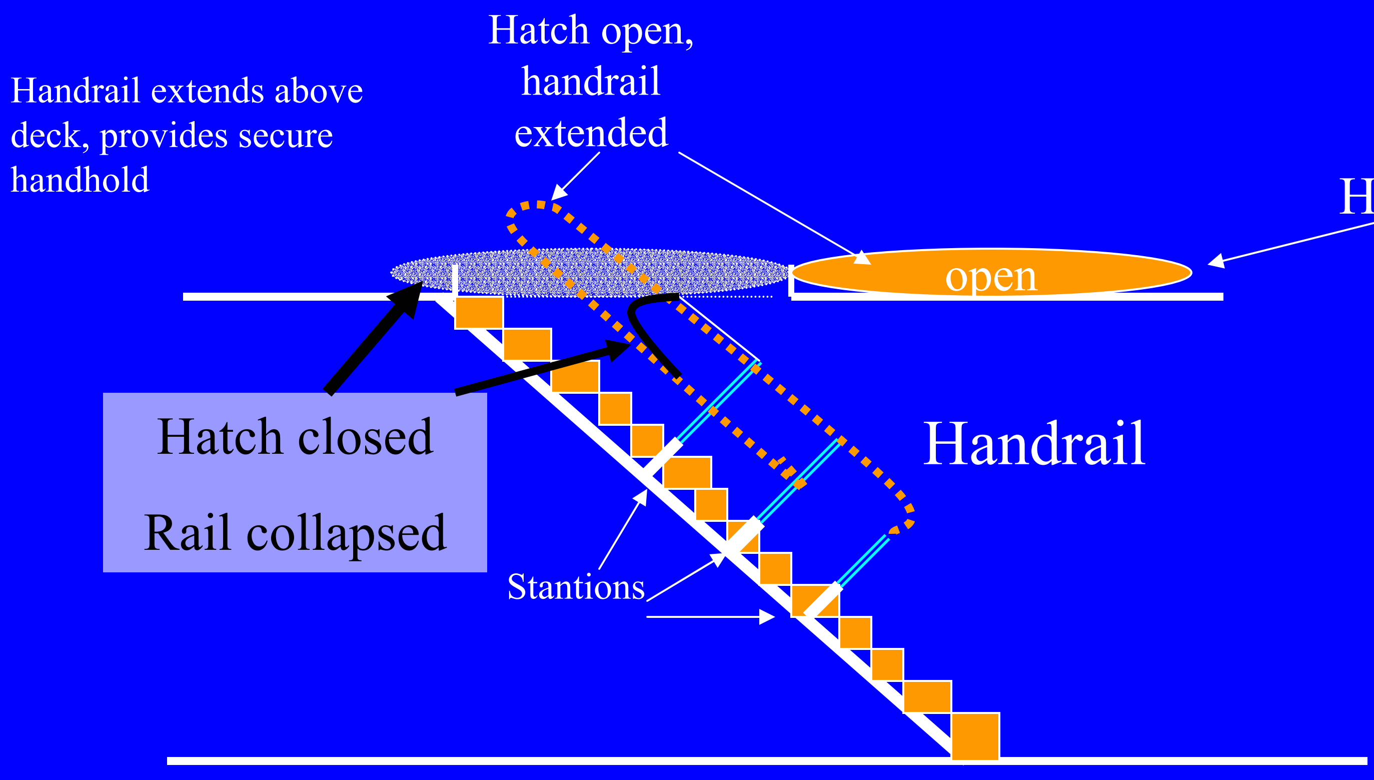
ALTERNATIVE HANDRAIL DESIGN FOR INCLINED LADDERS

Current design used where adjacent hatches provide watertight seal



NEW HANDRAIL DESIGN FOR INCLINED LADDERS

Provides for extendible handrail that collapses when hatch closes



APPROACHES TO SHIPBOARD INCLINED LADDER "STAIR" SAFETY

- Specifications and design guidelines for ladder angle.
  - Avoid the urge to increase ladder angle to allow more "crowding" of other items into the area
  - Provision for secure handrail at top of ladder
  - Maintenance of ladders – including tread

FALLS FROM BUILDING OR STRUCTURES

(Includes portable lifts and cranes)

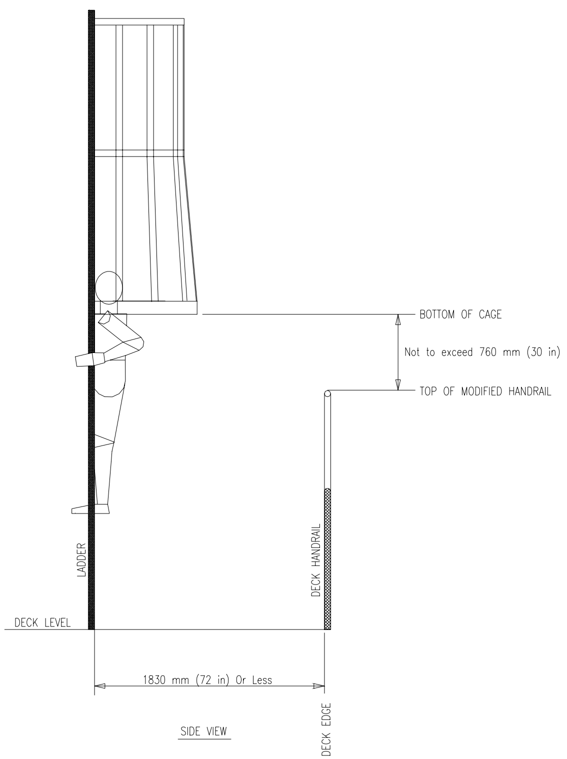
Key factors and prevention
Lack of guarding and secure ladders for climbing (especially cranes)*
Training –and use of approved harness (include design for secure and accessible anchorage points)
Ladders unguarded from crane movement*
Unguarded deck edges – guard all edges (using railing if feasible)*
* Amenable to engineering controls

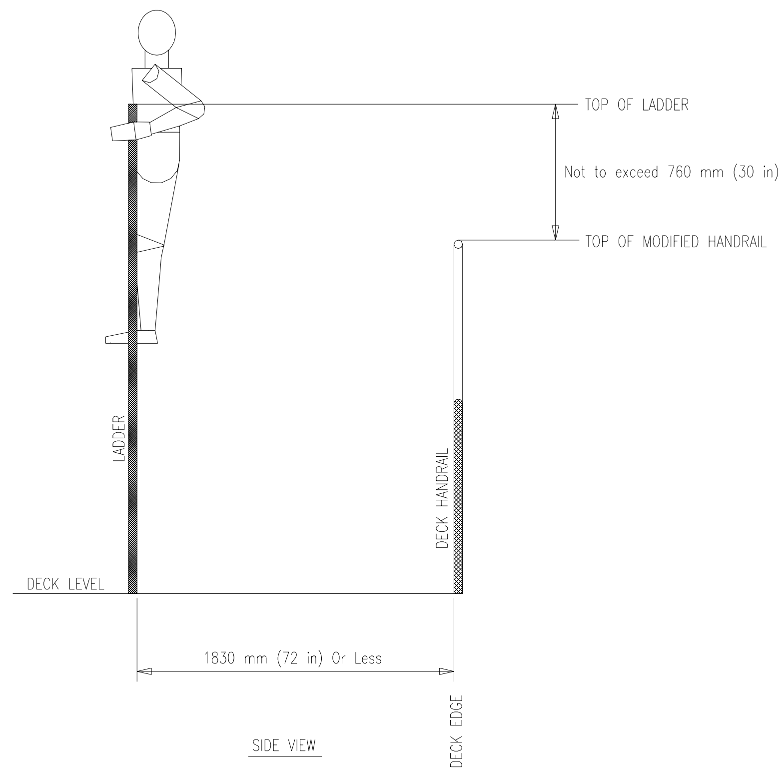
ABS HUMAN SYSTEMS INTEGRATION GUIDELINES

Draft **Vertical Ladders Near Deck Edges**

courtesy Denise McCaffrey see www.eagle.org

- Avoid locating <6 feet of edge
- Rail height > ladder distance





EDGE AND HATCH PROTECTION
Portable edge protection or rails

Courtesy Kee Industrial Products, Inc. - United States
Product shown for example –without product endorsement

http://www.keeguard.com/us/index.html

FALLS INTO HOLES OR OPEN SURFACES

Key factors and prevention * All amenable to engineering controls
Lack of guarding – guard all edges with rails when possible - including kick protection
Unguarded deck edges – guard all edges (using railing if feasible)
Use tank guards
Light area and Paint guards to improve contrast
Augment plastic covers with boards or other firm surfaces (train for hazard awareness for plastic covered surfaces)

FALLS INTO HOLES OR OPEN SURFACES

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Use tank guards*
Light area and Paint guards to improve contrast*
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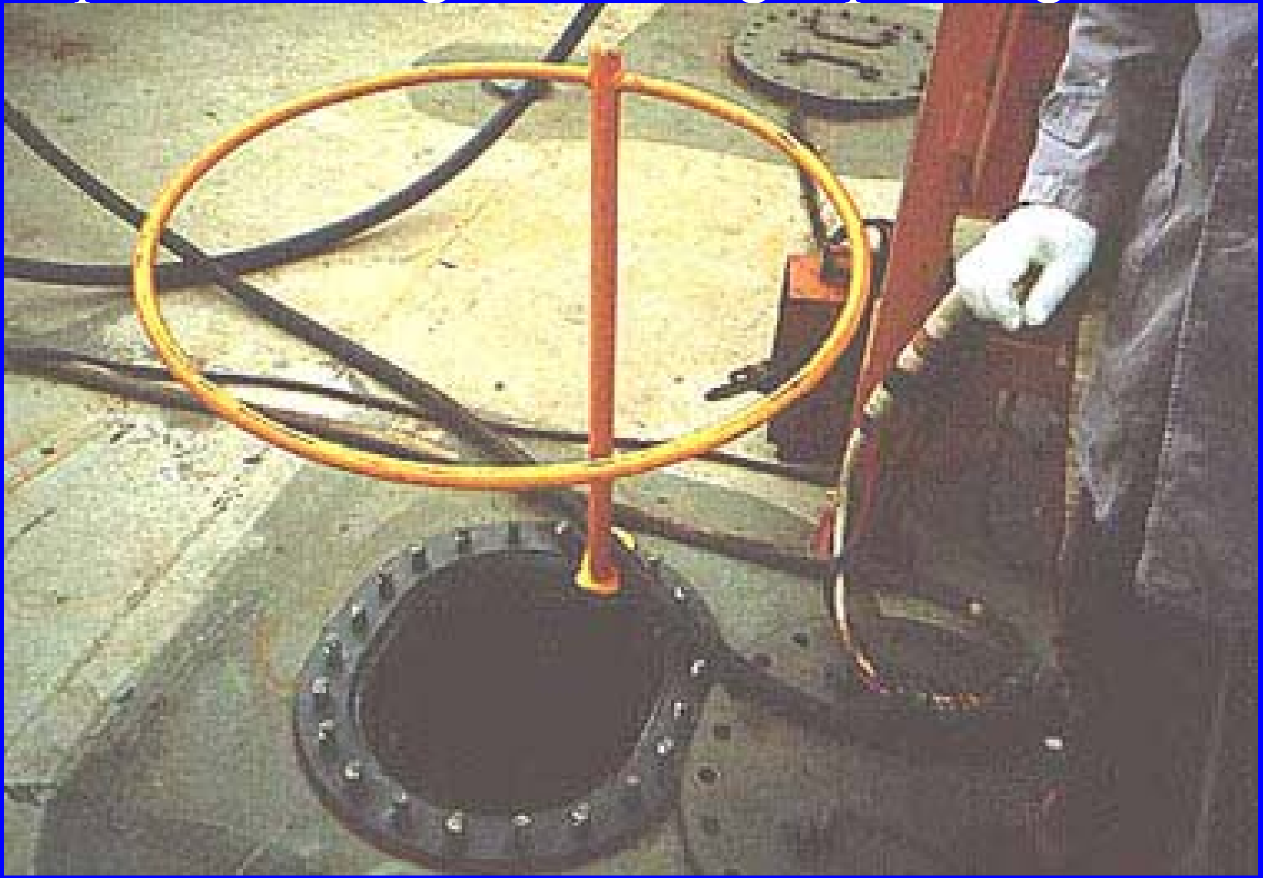
FALLS INTO HOLES OR OPEN SURFACES

Hatch guard from Japanese shipyard
(NIOSH Evaluation of Shipyard Ergonomic Hazards)
http://www.cdc.gov/niosh/ergship/hatchguard.html



SCAFFOLDING

http://www.osha.gov/SLTC/etools/shipyard/shiprepair/

DESIGN ISSUES NEED TO SUPPORT USE OF PERSONAL FALL PROTECTION EQUIPMENT

(Alternative if other engineering controls are infeasible)

- Planning for construction and maintenance to include efficient and safe access
- Certified Anchor points (5000 lb) for personal fall arrest systems and scaffolding
  - Built into system
  - Designed for ready access
  - Minimize risk to “first man-up” and all who follow

FALLS FROM SCAFFOLDING

Key factors and prevention * Amenable to engineering controls
Lack of guarding – guard all edges with rails when possible - including kick guards
Poor traction – use planks with high coefficient of friction (including metal planks with friction grating)
Replace scaffolding with mobile lifts where feasible
Ensure safe access to scaffolding (ladders with guards or safety rail or guarded stairs)

FALLS FROM SCAFFOLDING (2)

Key factors and prevention * Amenable to engineering and management controls
-Qualified inspection before use -Ensure scaffolding is free of obstructions -Ensure proper construction and erection -Provide secure anchor points for fall arrest harness (5000 pound capacity)

FALL PROTECTION ISSUES MASTS AND AERIALS

http://pc-78-120.udac.se:8001/WWW/Nautica/Ships/Pommern3.gif

FALL PROTECTION ISSUES MASTS AND AERIALS

- Ensure that radar or radio is turned off and locked or tagged out (29 CFF1915.95)
- Design to avoid need to climb masts
  - Example Triangular versus square sails
  - Masts that rotate from base (similar to street lights)
- Safe ladders and Climbers safety rail or other fall protection “built-into” system
- Location of ladders and access points away from edges or protected by guard rails
- Safe means to bring up and secure tools and equipment

CRANES, HOISTS AND OTHER ELEVATED WORK SURFACES

- Specialized (and often isolated) work force
- Initial access to crane
  - Ladders poorly designed
  - May need retrofit for safety cage or safety rails)
- Crane motion –potential to impact workers
  - Isolate path of motion, if feasible
  - Markings and warnings
  - Edge protection in area and life vests as last line of defense

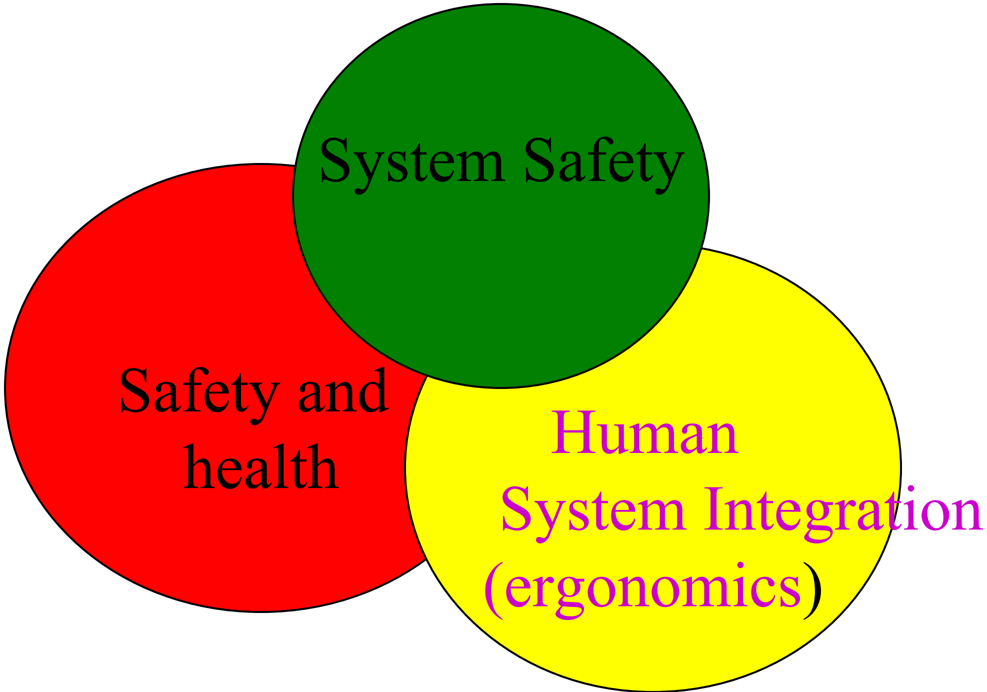
CRANES, HOISTS AND OTHER ELEVATED WORK SURFACES

- Specialized (and often isolated) work force
- Atmospheric hazards may still be present
  - Large enclosed bays
  - Combustion sources (exhaust gases tend to rise)
- Emergency egress
  - Lightening and high winds
  - Ladders may be poorly designed
  - May need retrofit of emergency escape equipment
  - Pre-planning for communications
  - Fire and emergency pre-planning

Identify issues
Statistics
Existing design
New design
Management
Future needs & focus

OCCUPATIONAL SAFETY AND HEALTH, SYSTEM SAFETY AND HUMAN SYSTEM INTEGRATION

- All overlap with risk management and cost-containment



Identify issues
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THE BUSINESS CASE FOR FALL PROTECTION IN SHIP DESIGN

- Fall accident data reviewed.
- Two problem areas and potential design alternatives highlighted.
  - (Many others could be added).
- Design alternatives for deep tank access
- Cost avoidance information
- Technical and management approaches discussed.

Fall protection and it's link to Human Systems Engineering

Fall protection =

Measures to prevent falls from heights (typically above 5 feet)

- **Where feasible, the hazard should be mitigated by engineering controls designed into the system.**

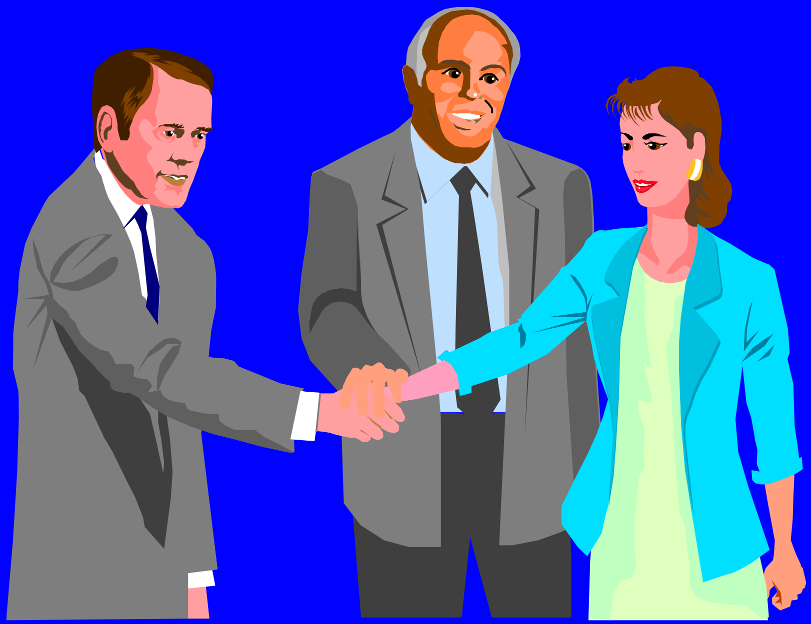
Human systems engineering =

Design of systems that match the capabilities of the people designed to operate and maintain them and avoid or mitigate hazards

CONFINED SPACES BUILT INTO SHIPS
Combined fall hazard and confined space

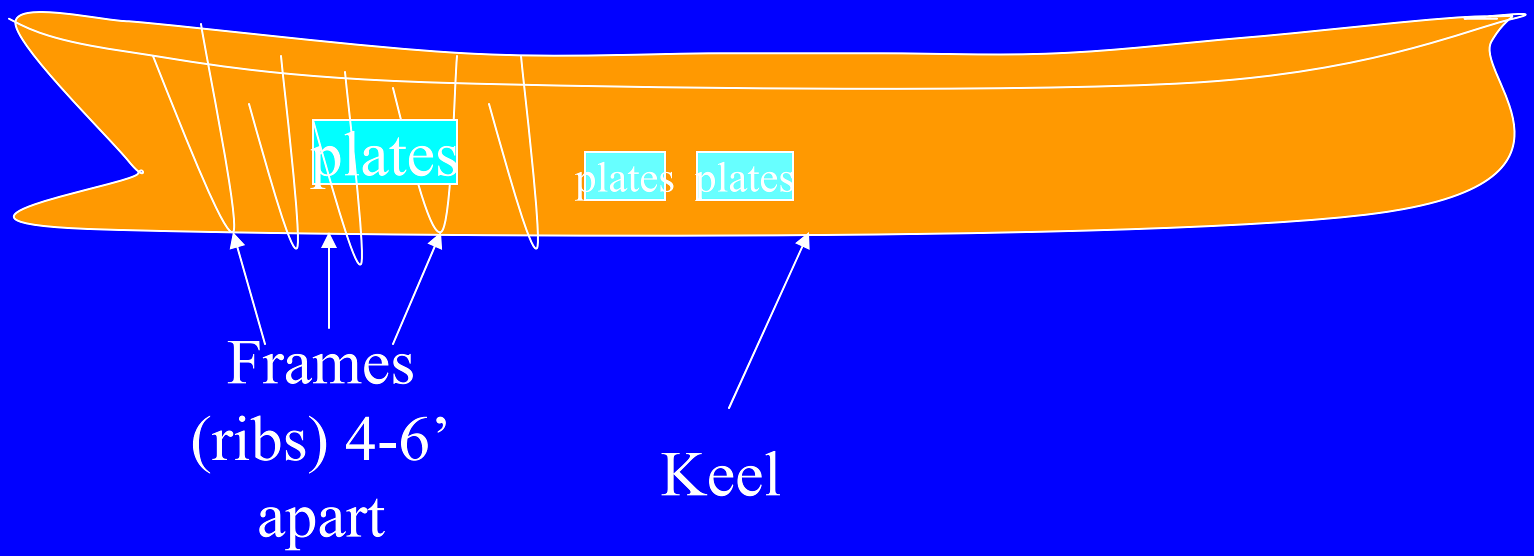
- Design and maintain to minimize need for access
  - Long life paint systems
  - Isolated tanks not needing routine painting
- Design for safe and efficient access
  - Access port
  - Ladders (include safety rails)
  - Anchor points for scaffolding and fall arrest systems
  - Consider emergency rescue
- Initial access and inspection most difficult
  - Preliminary and ongoing purging and atmospheric testing
  - Redundant fall arrest (ladders may be corroded)
  - Communication and rescue pre-planned

Management Approaches and Role of the Process Action Team

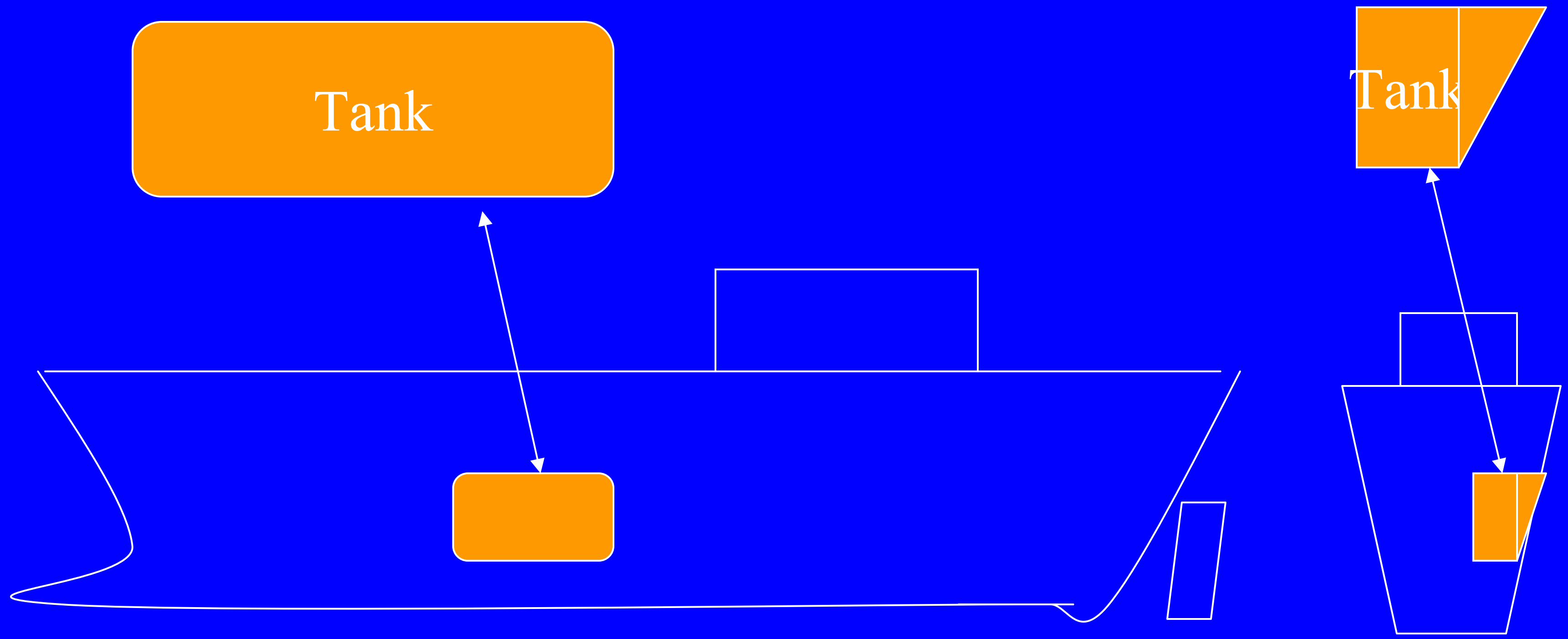


- Integrated efforts of designers, shipyards (construction and repair facilities), end-user and safety experts
- Requirements for life cycle cost and risk management

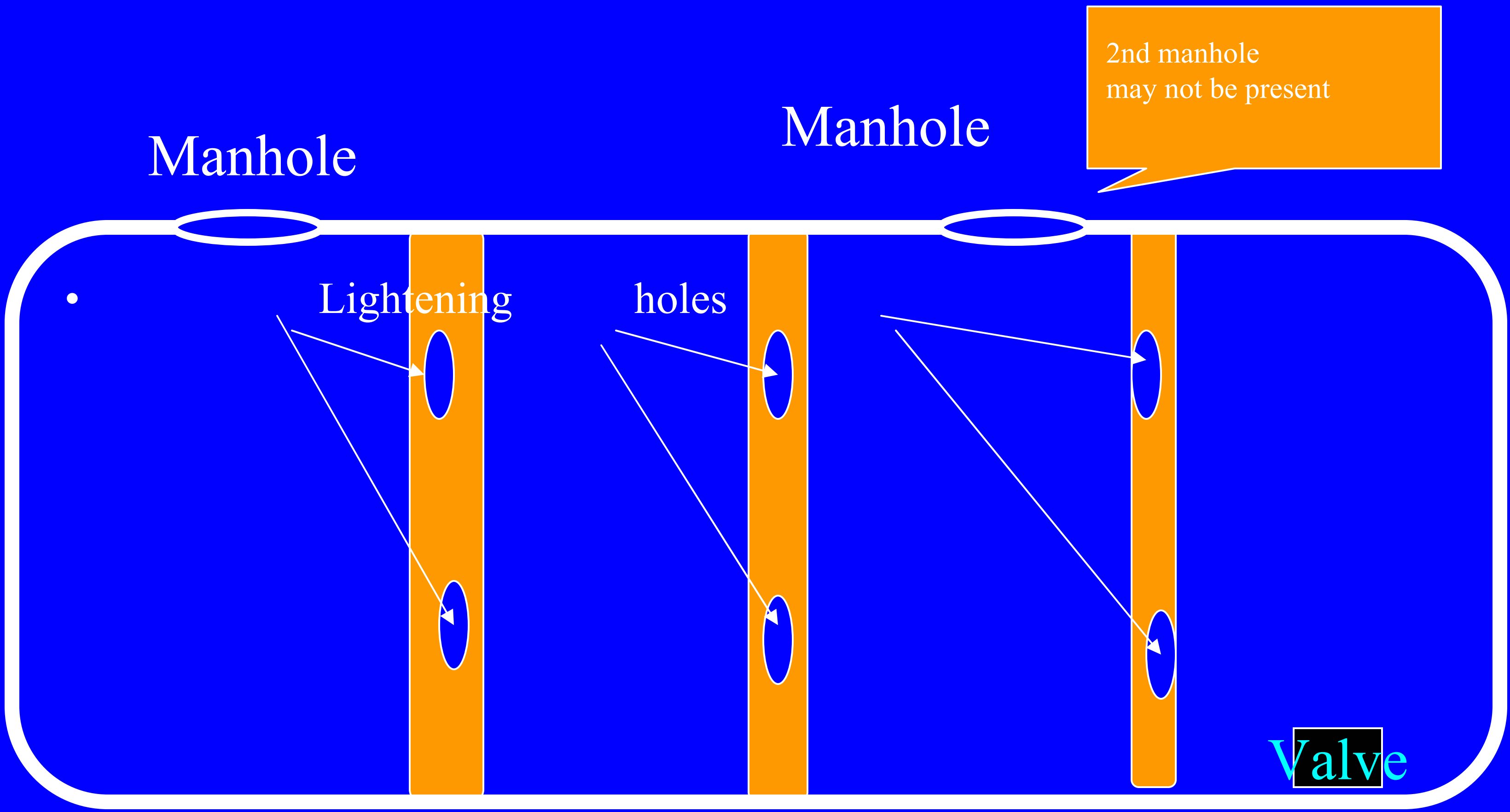
Conceptual ship construction model
(Ships are now built in modular blocks)



Ship construction and tank location



Configuration of a “Typical” Deep Tank (elliptical holes 18”minimum diameter)



AIRCRAFT CARRIERS (CVNS) AND THEIR WING-DEEP TANK ISSUES

- Deep tanks generally span 4-5 frames, (t-bulkheads)
- Swash holes “lightening holes” are elliptical passages of 18” minimum diameter
- Configuration poses a combined confined space and fall hazard with need for Personal Fall Arrest System (PFAS) *

* Complicated by the tank’s design features

CVNS AND THEIR WING-DEEP TANK ISSUES

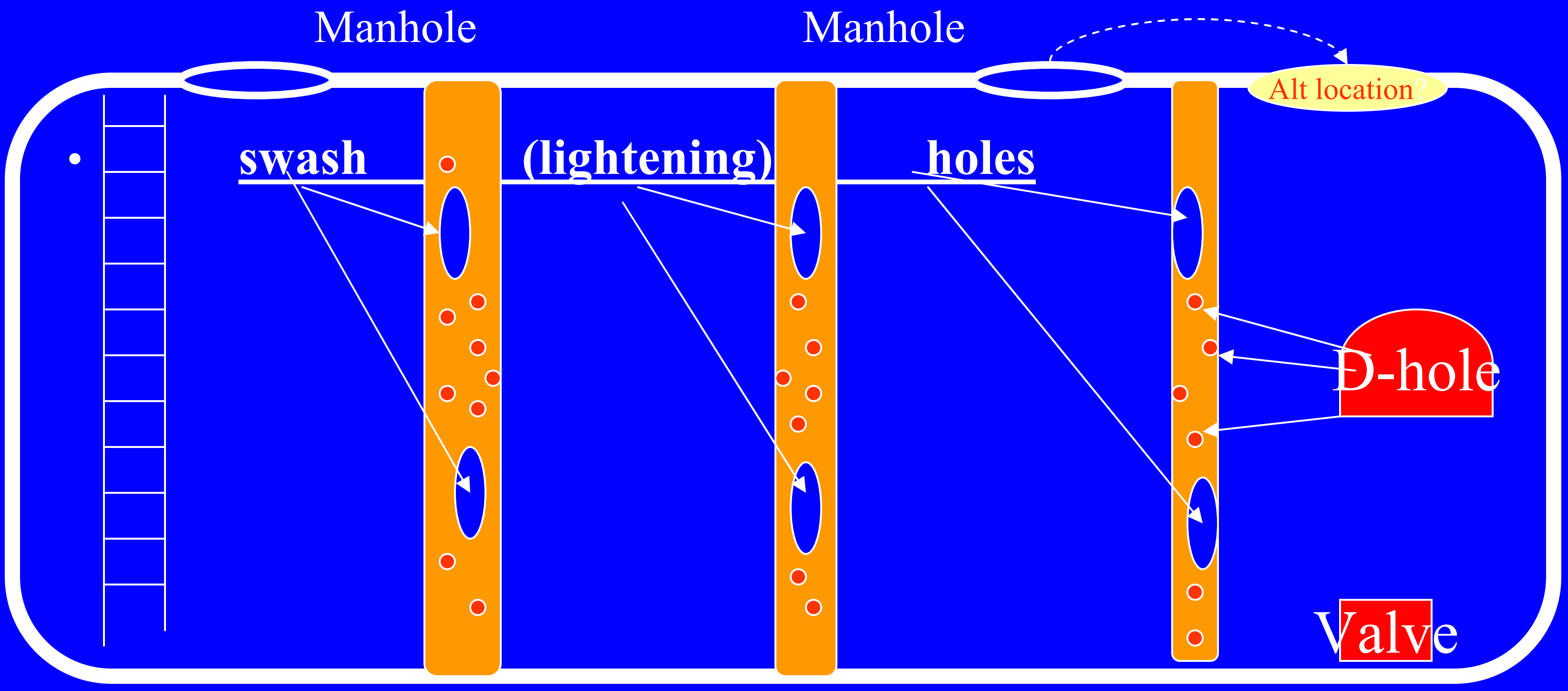
- Approximately 150 tanks and 350 voids in a typical CVN.
- These deep tanks extend down to 60-70 ft with hull design, space constraints, sloping sides all creating multiple configurations.
- Tank access is through a top hatch with no transition to internal transverse t-bulkhead with D- holes.

"TYPICAL" DEEP TANK ACCESS ISSUES

"D"- holes not considered bona fide ladders

(No fall restraint and/or arrest. One slip means-meeting the tank bottom)

- Placement as far as 3 feet apart!
- Difficult transition between frames (t-bulkheads) 5 - 6ft apart



CVNS AND THEIR WING-DEEP TANK ISSUES

- D-holes do not meet the criteria of a safe ladder (Official OSHA interpretation-PSNS)
- D-holes lack PFAS and/or climbing assists
- D-holes may be as much as 3-4 ft apart and absent at the tank tops with their spacing irregular at swash holes in the t-bulkheads
- Use of PFAS made complicated by lack of anchorage points inside of these tanks

CVNS AND THEIR WING-DEEP TANK ISSUES
Complications introduced by confined space issues

- Challenging environment: limited access, poor lighting and ventilation, possibly wet or surface petroleum residues.
- Potential for oxygen deficiency or introduced contaminants (blasting, painting) requires use of SCBAs or airline making the use of fall protection a "greater hazard."
- If a person "goes down" in a far space, need is established for a high angle rescue team.

PUGET SOUND NAVAL SHIPYARD (PSNS) INNOVATIONS TO ADDRESS FALL HAZARDS

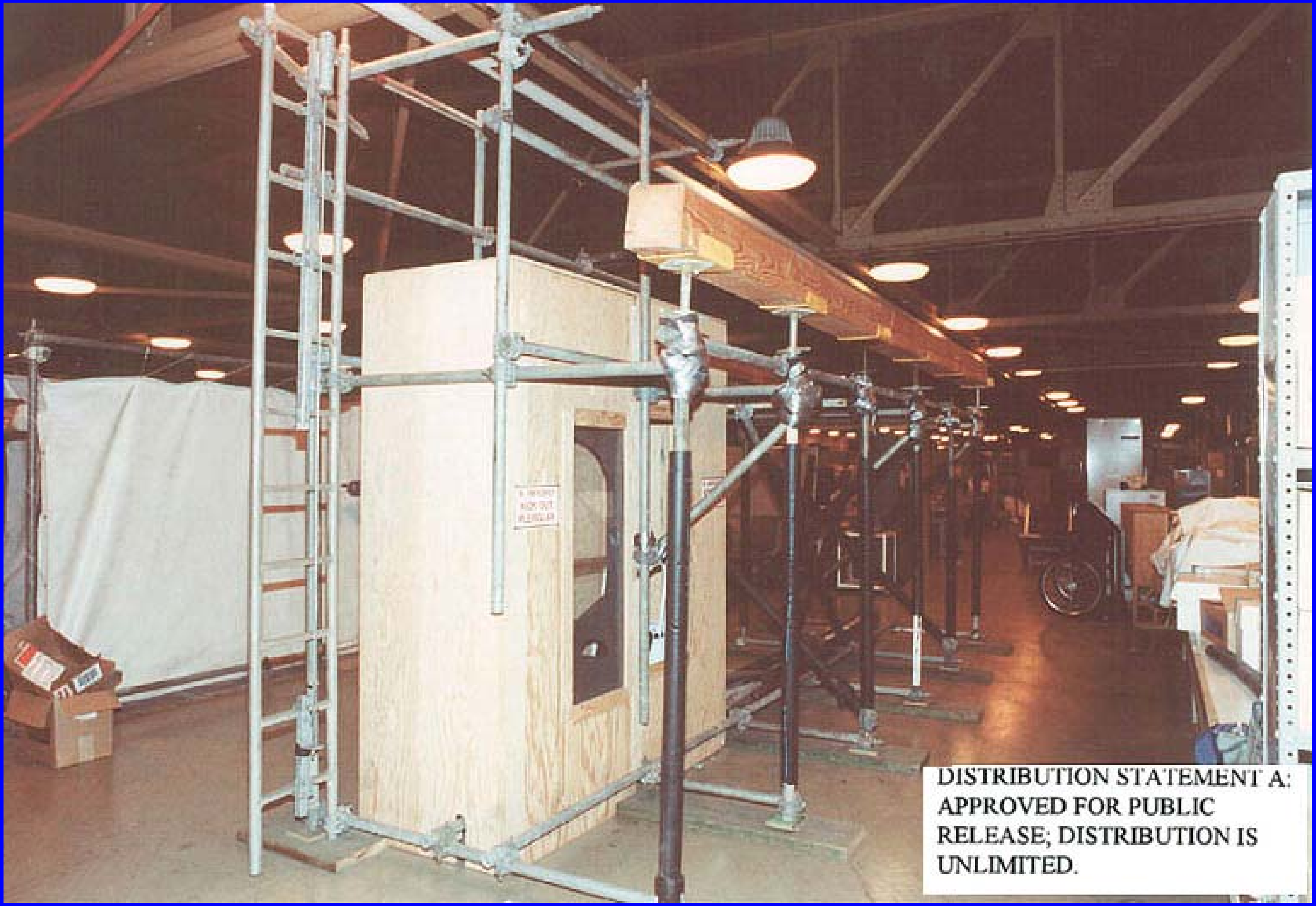
- PSNS developed and patented
  - "D-hole connector" (Provides stable anchorage point).

  "Beamer"- a mobile anchorage point for an I or T beam stiffener employed as a drag-along trollying device.
- PSNS first man up device- which allows for an extended reach to set up a carabineer and snap hook for establishing an initial PFAS

- PSNS Fall protection kits- harness, tie-off adapter(nylon webbing with two D-rings(large and small), 2 carabineers, 2 safety lanyards - 3 ft and 6 ft w/2 legs

Entrance to training mock-up of deep tank (Puget Sound Naval shipyard)

TRAINING MOCK-UP OF DEEP TANK
(Puget Sound Naval shipyard)



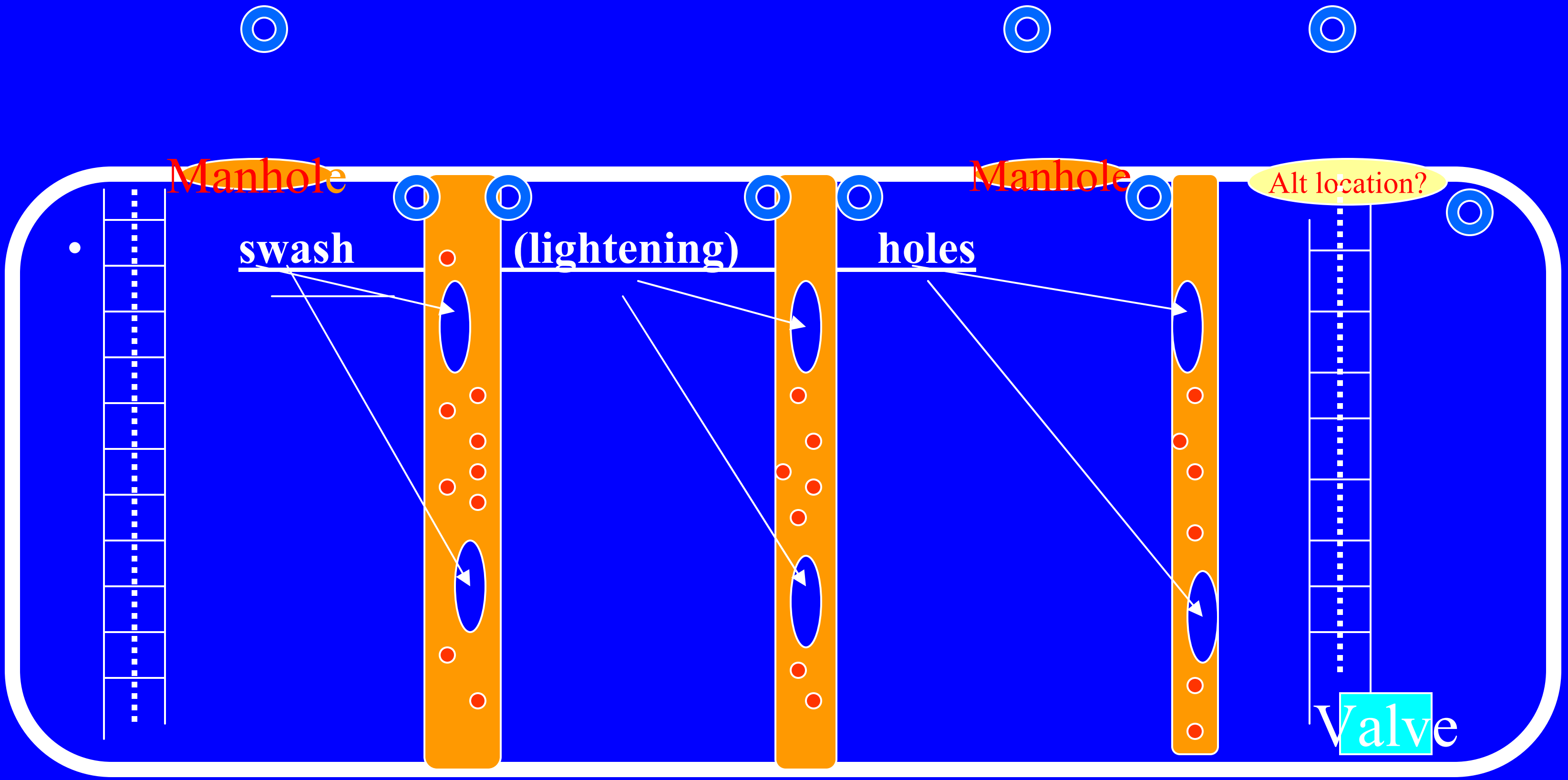
ANCHOR DEVICE USE IN DEEP TANK
(Puget Sound Naval shipyard)

POSSIBLE ALTERNATIVE DESIGN APPROACHES

-Additional anchor points

above manholes, near tops of tanks (need to avoid swing falls)

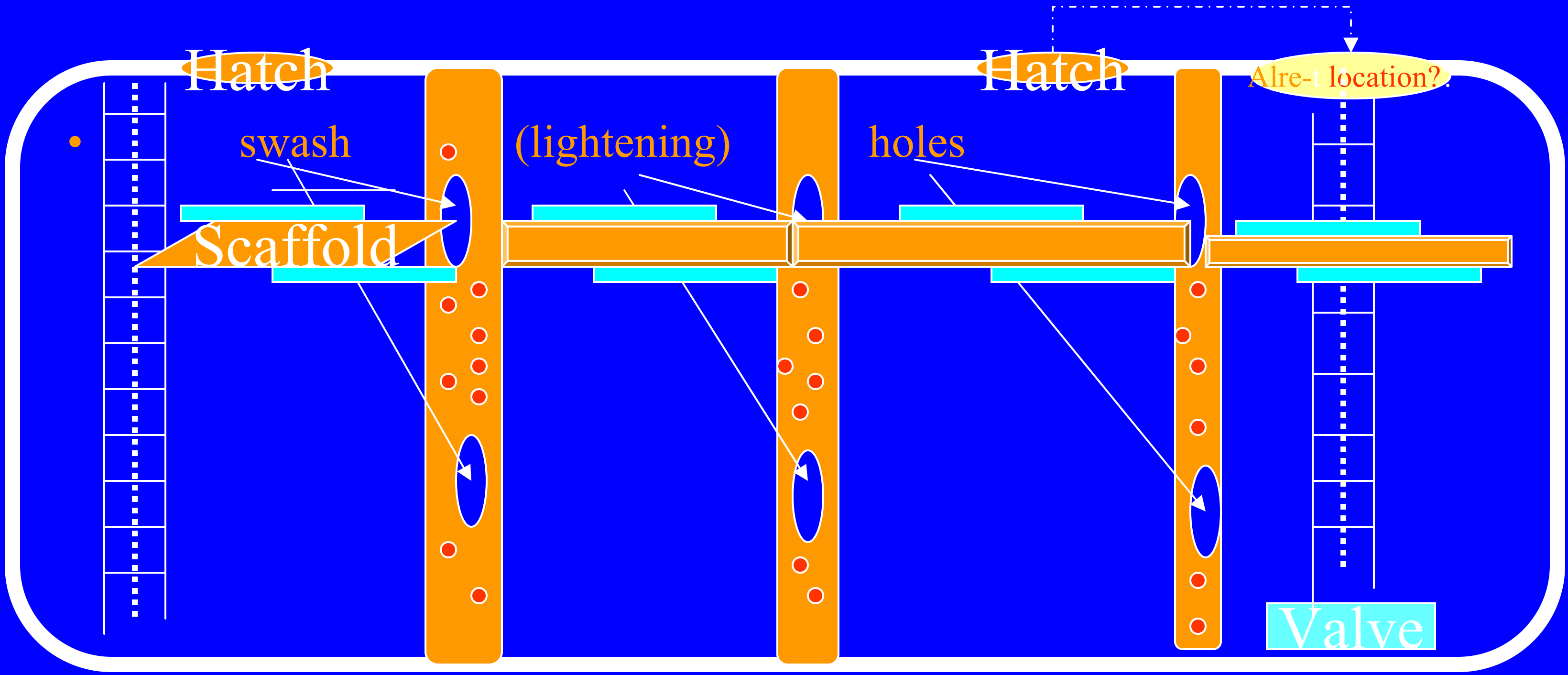
- Additional climbing footholds and ladders.



POSSIBLE ALTERNATIVE DESIGN APPROACHES-

-Horizontal stabilizers or welded bracket (on both sides) for scaffolding placement

(Any design alternatives must be developed by marine architect)



SPECIFICATION APPROACH

Parameter	Tentative Criteria
Size of D-ring or other footing	Same (large enough for boot)
Fall protection approach for vertical ladders	Ladder climbing device (existing spec.)
Minimum elliptical diameter	Per ASTM F1166 One location should accommodate SCBA rescue
Tie off provisions for personnel & scaffolding	5000 lb anchor point with access at hatches and along climbing areas.
Maximum distance between footings and transitions	Per ASTM F1166 Typically 12 inches

COMMON ASSUMPTIONS RE: OCCUPANCY OF DEEP TANKS

1. Areas are not often occupied.
   - Generally true during deployment
   - Not true during shipyard availability
2. Few people enter these areas
3. Improvements in access would be difficult to engineer

COMMON ASSUMPTION 1.

Limited entry and cost for tank access

Labor cost $58 hour– Additional time for entry precautions cost $$

40-50 tanks at 8th deck levels with about 1/3 or 14 of them being available for an inspection at any given time.

150 Tanks per carrier, about half entered during a typical availability (each two years)

About 350 voids, not routinely entered or occupied. Periodic inspection and maintenance and access to some other areas

COMMON ASSUMPTION 2
Few people enter these areas

Trades involved with tank maintenance

Trade	Crew size	Trade	Crew size
Gas free tech	2	Welders & fire watch	3
Shipwrights	4	Marine machine	4
Tank cleaners	6	Riggers	2
Abrasive blasters	8	Tech support	3
Inspectors	2	Painters	6

COMMON ASSUMPTION 3
Changes would be difficult to engineer

- Human systems integration guidelines applied to design of tanks undergoing redesign*
  - Spacing of D-ring holes
  - Location of swash holes
    - Size of swash holes where feasible
    - Distance from inner bottom of tank
  - Consider additional padeyes at top of tank
  - Distance between entry and secure foothold

❖ Subject to structural evaluation by marine architect

INITIAL PROJECTIONS AND AREAS FOR ONGOING WORK:

- Analyze cost of improvements with relation to level of safety and productivity improvement.
- Demonstrate return on safety and health investment for integrating fall protection into the new ship's design.

LIMITATIONS OF MISHAP DATA

- Level of detail
- Root cause analysis (often lacking)
- **Workers ability to overcome potentially hazardous situations by labor-intensive precautions**

G.C. SIMPSON

COSTS AND BENEFITS IN OCCUPATIONAL ERGONOMICS

Ergonomics 1990 Vol. 33, No.3, 261-268

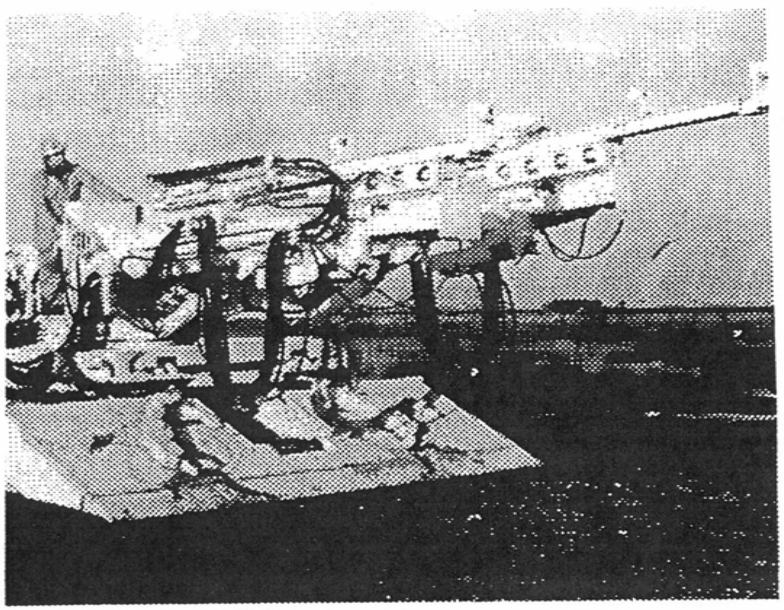
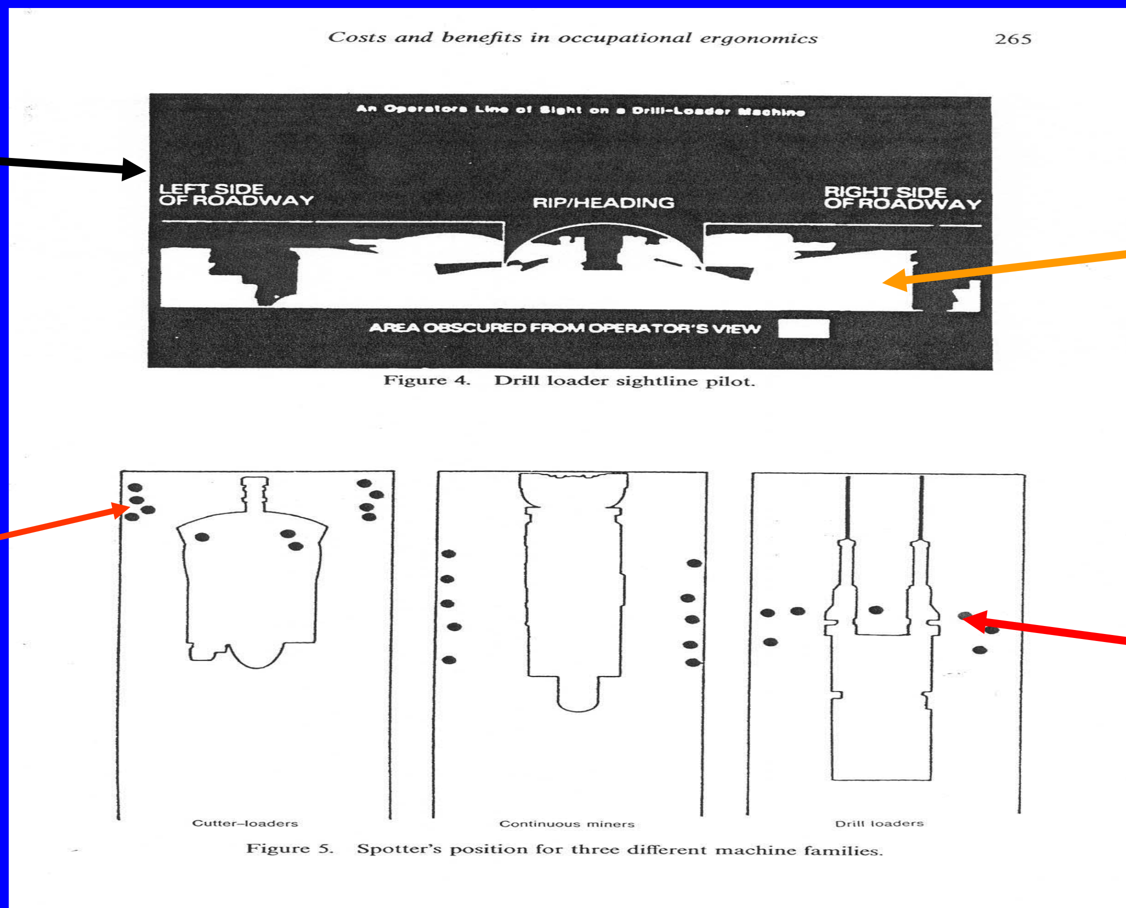


Figure 3. Drill loader.

Restricted visibility
Creates safety hazard
Requires 2 versus 1 man operation

Black area shows field of vision



White areas blocked from view- ***include critical work zone***

- Dots show position of “helper”

- Dots show position of “helper”

Operation of this machine took a special kind of man!

G.C. Simpson
Costs and Benefits in occupational ergonomics
Ergonomics 1990 Vol. 33, No.3, 261-268

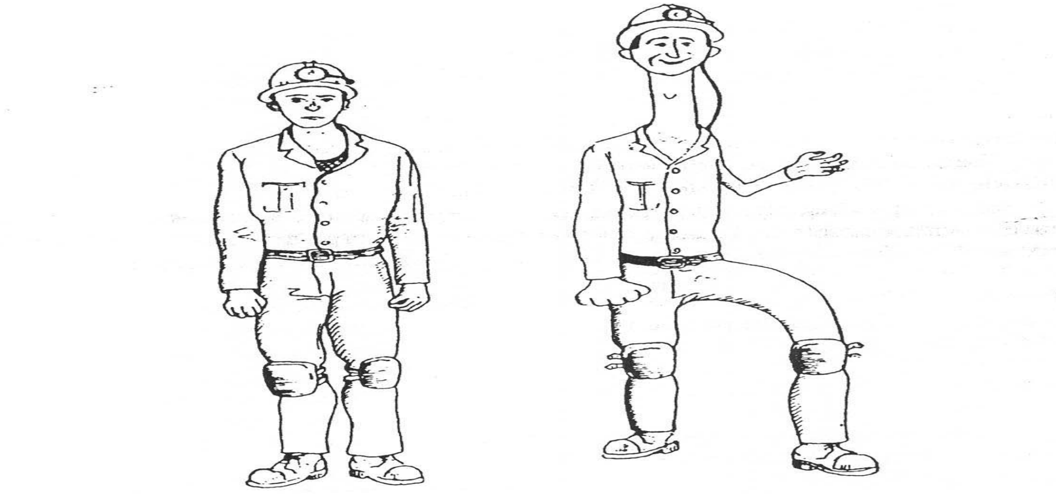


Figure 1. Man and 'Swadlincote man'.

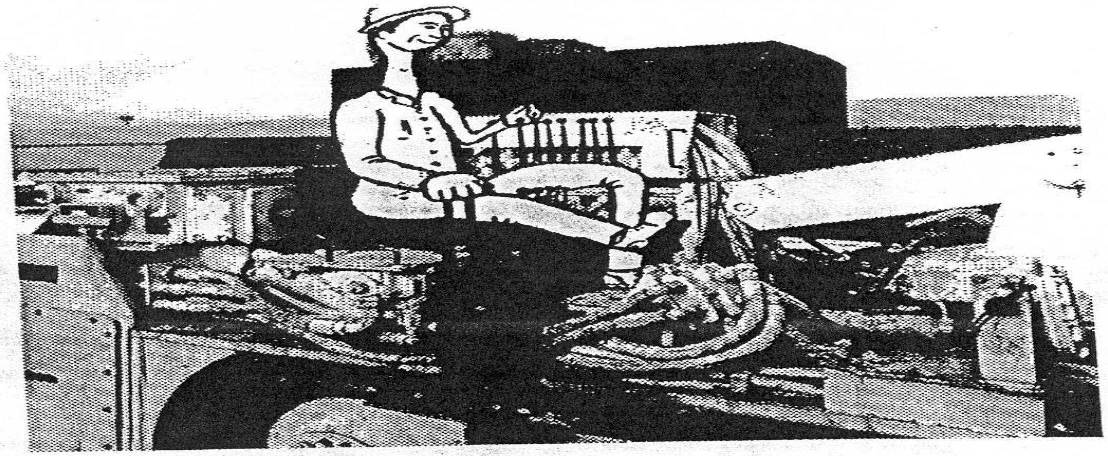


Figure 2. 'Swadlincote man' at work.

Happy worker adapted to the machinery.

It was extra labor cost, not accidents that forced the redesign of this machine!

TYPICAL DEEP TANK REFURBISHING OPERATION
COST AVOIDANCE ASSOCIATED WITH IMPROVED ACCESS

	Present	Present	Proposed	Proposed	Savings	Savings
Number of entries/ personnel	Work time (hours)	Cost ($60/hr)	Work time	Cost ($60/hr)	Work time (hours)	Cost ($60/hr)
42	88	$21.2K	55	$13.3	32	$7.9K

WHY THE LABOR SAVING?

- Padeye (anchor point) at top of manhole
- Improved access at top level
- Reduced time to move equipment
- Reduced time to set up scaffolding
- Reduced time at the base of tank and less time going between frames
- Intangible: Workers improved feeling of security

POTENTIAL COST AVOIDANCE FOR RELATED TO IMPROVED TANK ACCESS

	Present design	Proposed design	Cost savings	%
Job total $$ Typical tank	**$ 21,828**	**$ 13,640**	**$ 8,488**	**38**
Per yard period (30 tanks)	**$ 654,840**	**$ 409,200**	**$ 245,640**	38
Lifetime (speculative) 18 yard periods	$11.8M	$7.4 M	$4.4M	38

PLAN EARLY FOR COST SAVINGS AND RISK MANAGEMENT

Fall protection costs for construction

(Source: NAVFAC Fall Protection Guide)

- $1 at preliminary design phase
- $10 if designed after other systems
- $100 if designed during initial construction
- $1000 if installed after facility is built

SUMMARY - SHIPBOARD FALL PROTECTION

- Accident experience in the Navy and in the private sector indicate that there are current problems.
- Falls from height and on same level both deserve attention.
  - Severity ~~Drama~~ versus frequency
- Management and Design approaches identify and manage risks while reducing costs

APPROACHES TO IMPROVE SHIPBOARD INCLINED LADDER "STAIR" DESIGN

- Improve general design for material handling in other areas
  - Elevators
  - Conveyors
  - Manage traffic patterns to reduce the need to carry equipment on ladders

AREAS FOR MANPOWER SAVING

Area	Manpower Saving	Safety and health benefits
Materials handling	Reduce manpower	Reduce back & ladder fall injuries
Heat stress control	Reduce work-rest cycle	Lower heat stress risk
Remote sensing	Reduced inspection	Lower noise & heat exposure
Design for access	Reduced manpower	Reduced fall hazard

SYSTEM SAFETY RISK EVALUATION

Risk Area	Potential severity	Anticipated Probability	Remarks
Falls (tanks)	Catastrophic	Moderate	Likely to occur in system life
Falls inclined ladders	Moderate	Moderate to High – Depending upon design	Influenced by design. **Poor design likely to create unacceptable risk**
Falls on deck (with edge protection)	Moderate	High	May be acceptable risk
Falls on deck (no edge protection)	Catastrophic	High	Critical if ships designed for low radar signature

SUMMARY

- Personnel risk and total ownership costs for shipboard tanks can be reduced by use of HSI criteria in design
- Human systems integration can reduce manpower while improving safety and productivity.
- Need to consider materials handling, walking and working surfaces, maintenance and user safety in design.
- Risks need to be considered in system safety evaluations

ADDITIONAL SOURCES OF INFORMATION

- Naval Occupational Safety and Health NAVOSH website
  - www.NAVOSH.net/acquisition
  - www.NAVOSH.net/successstories
  - (check under ergonomics)
- OSHA website addressing shipyard safety
  - www.OHSA.gov
  - Naval Facilities Engineering Command
  - Construction Safety and Fall Protection
  - http://www.navfac.navy.mil/safety/site/Fall/fall.htm

ADDITIONAL SOURCES OF INFORMATION

- National Institute for Occupational Safety and Health NIOSH website
  http://www.cdc.gov/niosh/ergship

- American Bureau of Shipping Human systems integration website addressing safety in design www.eagle.org

MANY THANKS TO..

- J. Michael Sweeney, ALCM, ARM

  (Maryland Department of the Environment)
  - Previously with BMT/Designers and Planners, Arlington, VA

- Bill Nidel Member of CVNX ESOH IPT System Safety lead for this group

- Theresa Nelson, CSP, CHMM, Manager, Newport News Safety & Fall Protection and main liaison

- John Starcher, PE, Head OSH and Environmental Protection Office, NAVSEA SUPSHIP at Newport News

- Joel A. Korzun Aircraft Carrier Planning Dept. Code 1822 NAVSEA SUPSHIP at Newport News

MANY THANKS TO..

- Kenneth Congleton, Newport News Design Dept, Member of CVNX TAG, Newport News
- Louis Lee, Newport News Design Dept, Member of CVNX TAG, Newport News

- Lyon Jennings, Senior safety engineer, Newport News

- John Osgood Ergonomist Newport News

- James Scull Union Health and Safety Representative, Newport News

PUGET SOUND SHIPYARD SUPPORT

- Gerald McNeil, CSP
- Laura Mills
- Stewart Adams, CSP

- Basil Tominna, PE, Engineering Field Activity, Southwest Div. NAVFAC/Navy's Fall Protection Manager

Additional Slides and Information

REVIEW OF FALL PROTECTION REQUIREMENTS

Regulatory requirements related to fall protection

Hierarchy of controls stressing

– Design to avoid work at heights
– Provide protective devices
– Personal protective equipment and related training, management system

REVIEW OF FALL PROTECTION REQUIREMENTS

Regulatory requirements related to fall protection

- 5 feet or above in shipyards- related to scaffolding design
- Walking and working surfaces
- Design guidelines and requirements
  - ANSI Fall Protection Standards
  - ASTM F1166 Human Systems Integration in maritime systems

PERSONAL FALL ARREST SYSTEM

(Alternative if other engineering controls are infeasible)

- Fall protection requires comprehensive written program
- Training is required and essential
- Critical components must be selected and reviewed by competent professional as an engineered system
  - Anchorage system
  - Shock absorbing lanyard
  - Fall protection harness

PERSONAL FALL PROTECTION EQUIPMENT

(Alternative if other engineering controls are infeasible)

Example of typical equipment (Miller Equipment)*

** Examples show equipment **not** an integrated system*

- http://www.leonardsafety.com/leonardsafety.storefront/EN/catalog/1158

Fall Protection Methods and Approaches

- NAVOSH Quality Council's establishment of a Fall Protection Quality Management Board, chair-Basil Tominna P.E., NAVFAC
- QMB to standardize fall hazard analysis and establish criteria for fall protection equipment utilization, including specifications, selection, inspection, maintenance and quality assurance of FPE.

Labor cost $58 hour–Additional time for entry precautions cost $$

Notes: 40-50 tanks at 8 deck levels with about 1/3 or 14 of them being available for an inspection at any given time.

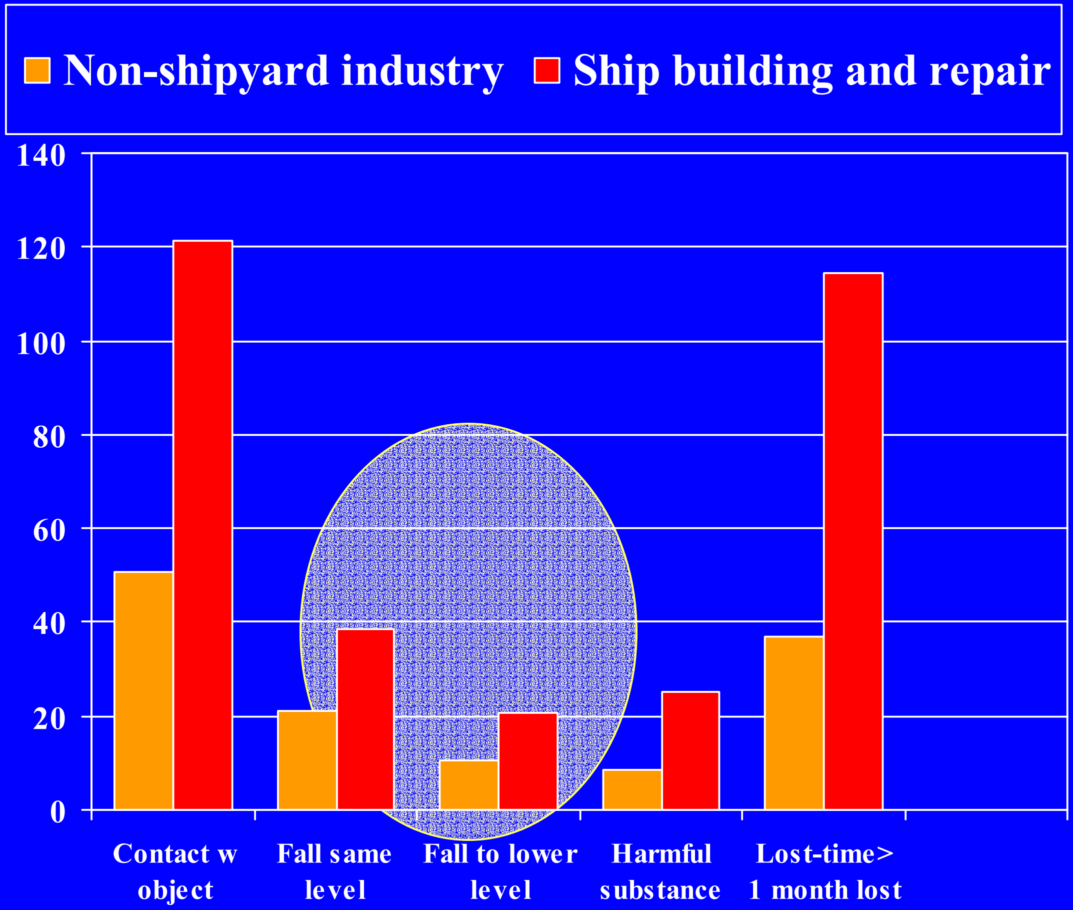
7. Shipfitters perform structural repairs on sheet metal (example: fix corrosion of tanks, tank ladders, baffle plates) Work is closely associated with welders and is performed during dry-docking
8. Electricians shop 51, provide electrical insulation of/for the sheet metal, whereas Temporary Services provides electric lights, ventilation and dehumidification inside tank voids.

Shipboard Ladders
Common Fall Hazard at sea and in port

- Vertical ladders
  - Transfer location a concern
  - Need climbers safety rail if >15 feet
- Inclined Ladders (“stairs)
  - Are very inclined
  - Most common location for ladder falls
- Jacobs ladders
  - (Over the side transfer)
  - May be highest risk but lowest frequency of mishap

NON-FATAL OCCUPATIONAL ILLNESS AND INJURY RATES FOR 1999

Rates adjusted per 100,000 man-hours



COMMON CAUSES OF FATAL INJURIES IN UK 2000-2001
All industries n=291
http://www.hse.gov.uk/statistics/2001/hsspt1.pdf

Category of injury	Total
Falls from height	73 (25%)
Struck by moving vehicle	64 (22%)
Struck by object	52 (18%)
Trapped by something collapsing or overturning	37
Total	291

United Kingdom
Slips, trips and falls in Shipyard industry

Health and Safety Executive Data 2001/2002

http://www.hse.gov.uk/aboutus/meetings/ships/041202/46e.pdf

Accident kind	Total
Slip	114
Trip	71
Twist	30
Fall on same level	16
Total	231

Common Agents in Shipyard Slips, Trips and Falls

United Kingdom Health and Safety Executive Data 2001/2002

http://www.hse.gov.uk/aboutus/meetings/ships/041202/46e.pdf

Common agents	Number of mishaps
Ladder	12
Gangway	13
Cables	14
Steps/stairs	23
Total	62 (of 231 cases)

NSRP Fall Best Practices for Slips, Trips and Falls Prevention

Summary information only

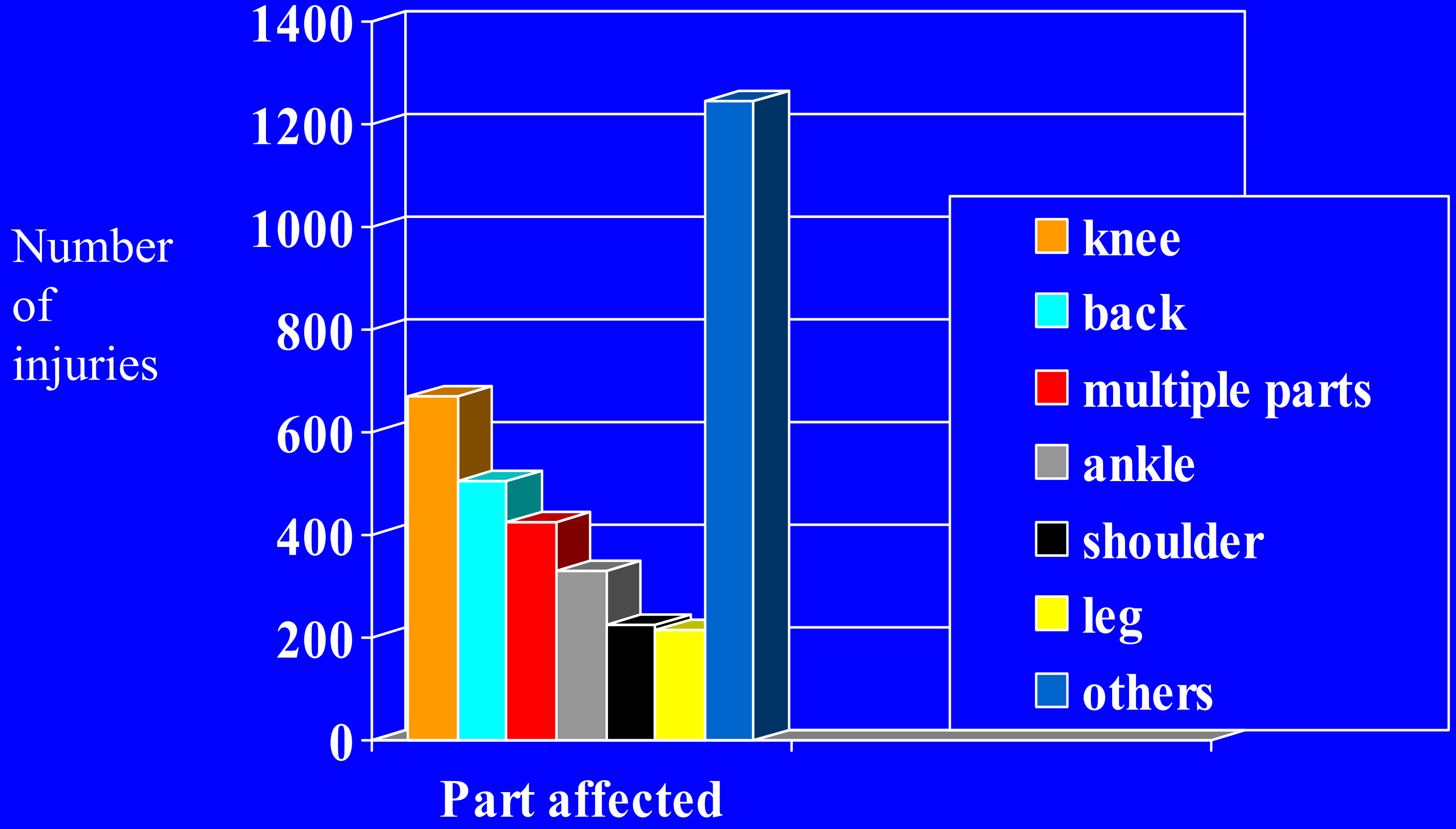
Report distribution limited to US Shipyards, NAVSEA and sponsors

National Shipbuilding Research Program 873-760-3366

Body Parts Affected by Falls

Body part(s) affected	Raw Number (3483 total)
Knee	669
Back	507
Multiple parts	424
Ankle	332
Shoulder	225
Leg	213
All others	1243

BODY PARTS AFFECTED BY FALLS
NSRP Best Practices Guide



SHIPYARD SLIPS, TRIPS AND FALLS

United Kingdom Health and Safety Executive Data 2001/2002

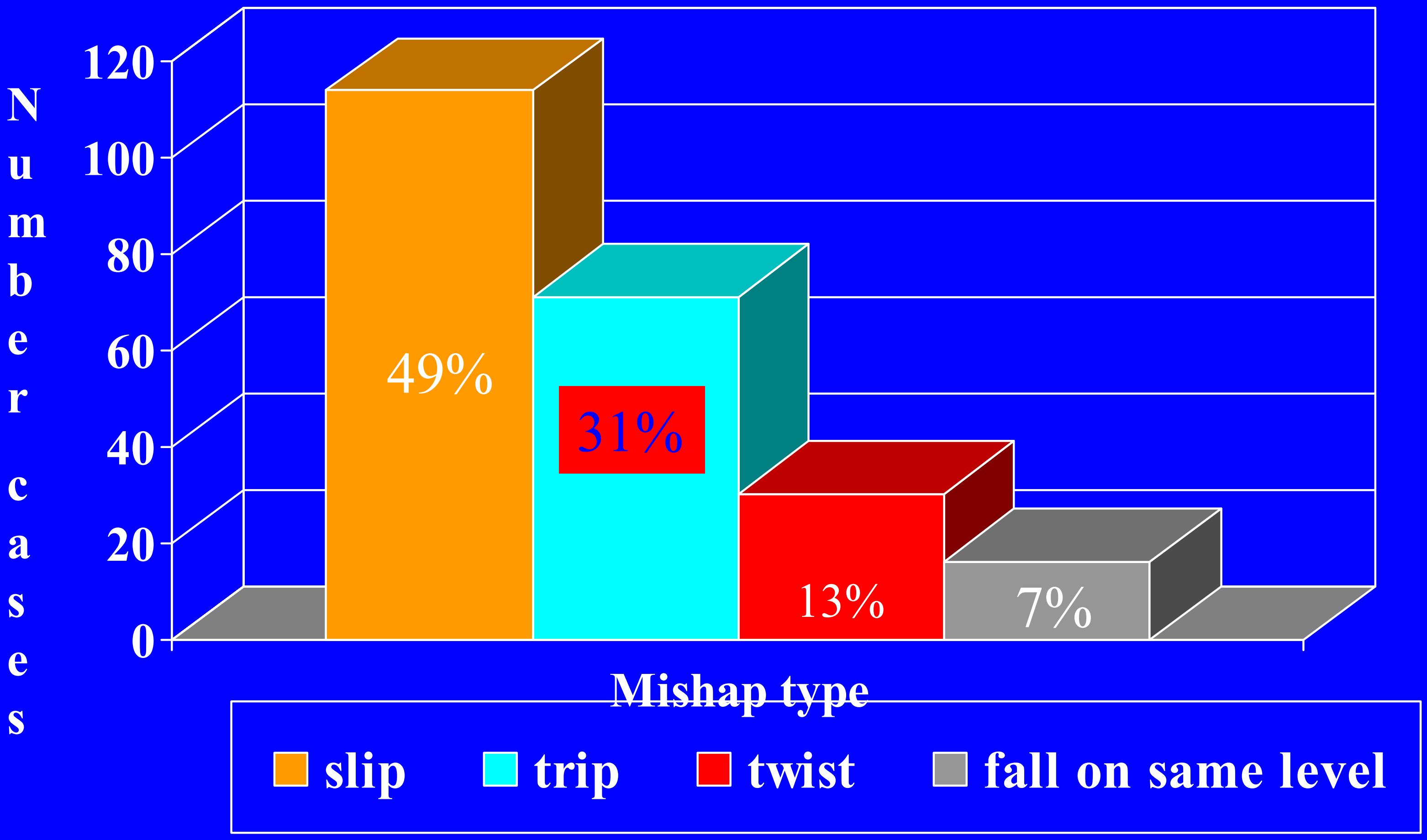
http://www.hse.gov.uk/aboutus/meetings/ships/041202/46e.pdf

Accident kind	Site	Vessel	Total
	Number		
Slip	52	62	114
Trip	42	29	71
Twist	17	13	30
Fall on same level	9	7	16
Total	120	111	231

SHIPYARD SLIPS,TRIPS AND FALLS (n=231)

United Kingdom Health and Safety Executive Data 2001/2002

http://www.hse.gov.uk/aboutus/meetings/ships/041202/46e.pdf



Major Participants

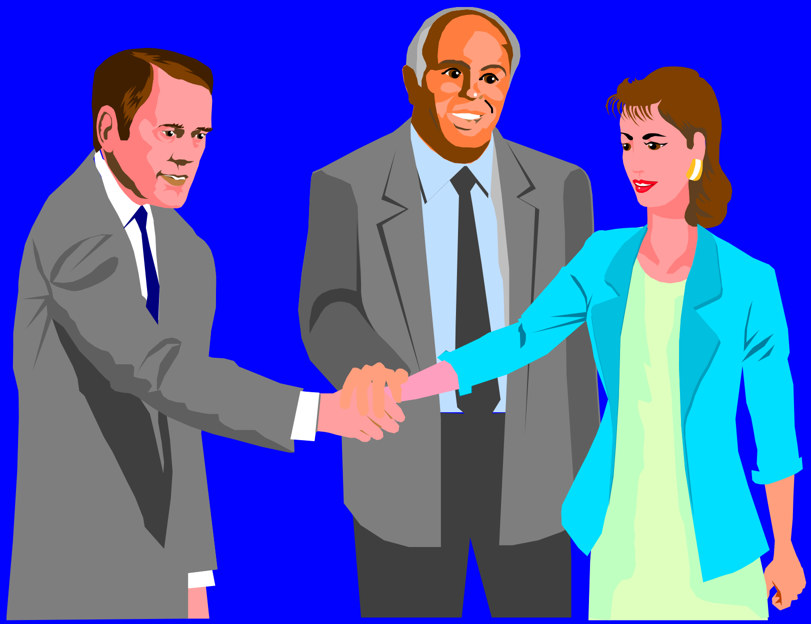
- Newport News Shipbuilding
- NAVSEA PMS 378, SUPSHIP, 00T
- Puget Sound Naval Shipyard
- NAVFAC/EFSC (Engineering Field Support Center)
- Chief of Naval Operations with BMT Designers and Planner's support

AIRCRAFT CARRIERS (CVNS) AND THEIR WING-DEEP TANK ISSUES

- Deep tanks generally span 4-5 frames, (t-bulkheads)
- Swash holes "lightening holes" are elliptical passages of 18" minimum diameter
- Configuration poses a combined confined space and fall hazard with need for Personal Fall Arrest System (PFAS) *

* Complicated by the tank's design features

Management Approaches and Role of the Process Action Team



- Integrated efforts of designers, shipyards (construction and repair facilities), end-user and safety experts
- Requirements for life cycle cost and risk management

DIFFERING APPROACHES TO TANK ENTRY

- PSNS adheres to requirement for fall protection even in the “greater hazard” scenario of the wing-deep tank.
- PSNS bridged the gap for PFAS and the need for fall protection with the “D-hole connector”device
- Commercial yards claim the “greater hazard” exemption for waiving the use of PFAS under most the challenging environment and emergency rescue situations- this leaves fall protection use literally “up in the air”

ALTERNATIVE APPROACHES AND CONCERNS

- Need to ensure fall protection at all times (possible exception of first man up)
- Current design and access issues
- Concerns that harness can impede access in some very tight locations
- Lack of acceptable tie-off locations

CRITERIA FOR SHIPBOARD CONFINED SPACE TANK

ENTRY AND ACCESS AIDS

Item   Description

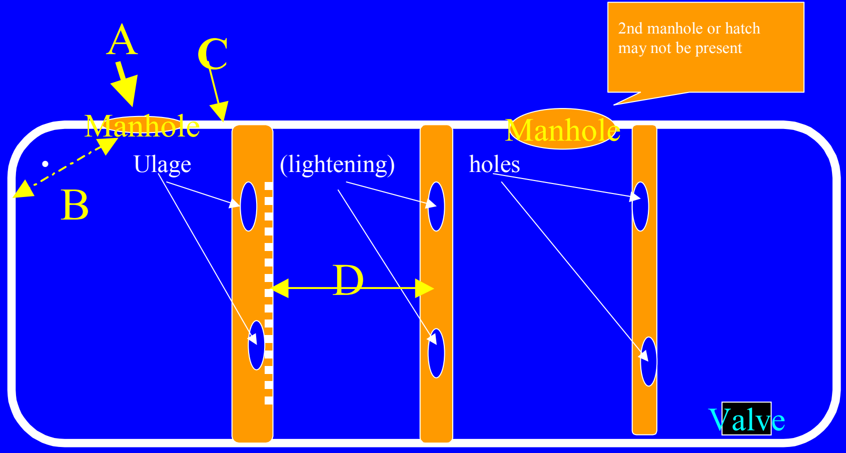
A   Manhole or access hatch

B   Space between entry point and secure foothold/ladder

C   Location and capacity of Anchorage points

D   Size, spacing and configuration of D holes (climbing rungs)

Configuration of a "Typical" Deep Tank (elliptical holes 18"minimum diameter)



CRITERIA FOR SHIPBOARD CONFINED SPACE

TANK ENTRY AND ACCESS AIDS

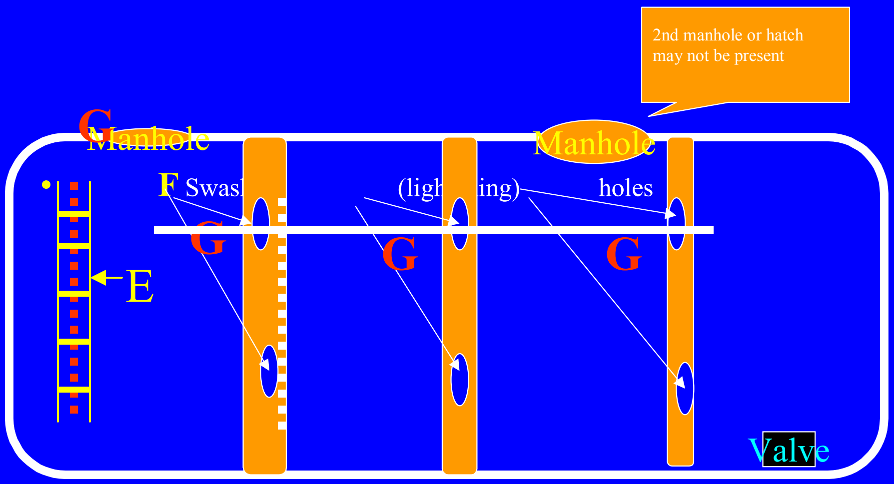
Item Description

E Ladder type and configuration

F Dimensions and orientation of lightening holes intended for passage

G Hardware to support scaffolding

Configuration of a "Typical" Deep Tank (elliptical holes 18"minimum diameter)



CRITERIA FOR SHIPBOARD CONFINED SPACE

TANK ENTRY AND ACCESS AIDS

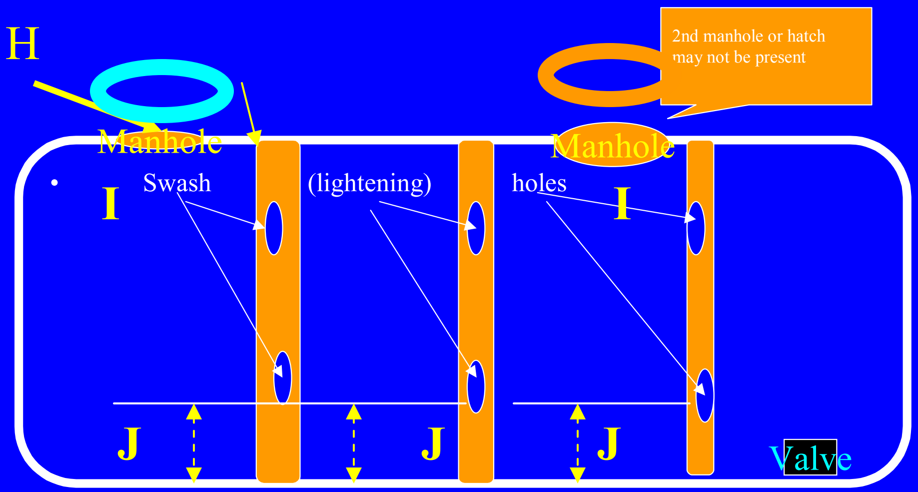
Item   Description

H   Perimeter Protection for Manhole or access hatch

I   Number and position of manholes

J   Height from lowest lightening hole to bottom of tank

Configuration of a “Typical” Deep Tank (elliptical holes 18”minimum diameter)



ANCHORAGE DEVICE DEVELOPED BY PUGET SOUND NAVAL SHIPYARD

Supplemental Efforts

- Working with NAVSEA (David Anderson) to upgrade ASTM F1166 Human Systems Integration in Marine Systems to address access in confined spaces
- Coordination with ABS (Dr. Kevin McSweeney) re human systems integration in ship design.

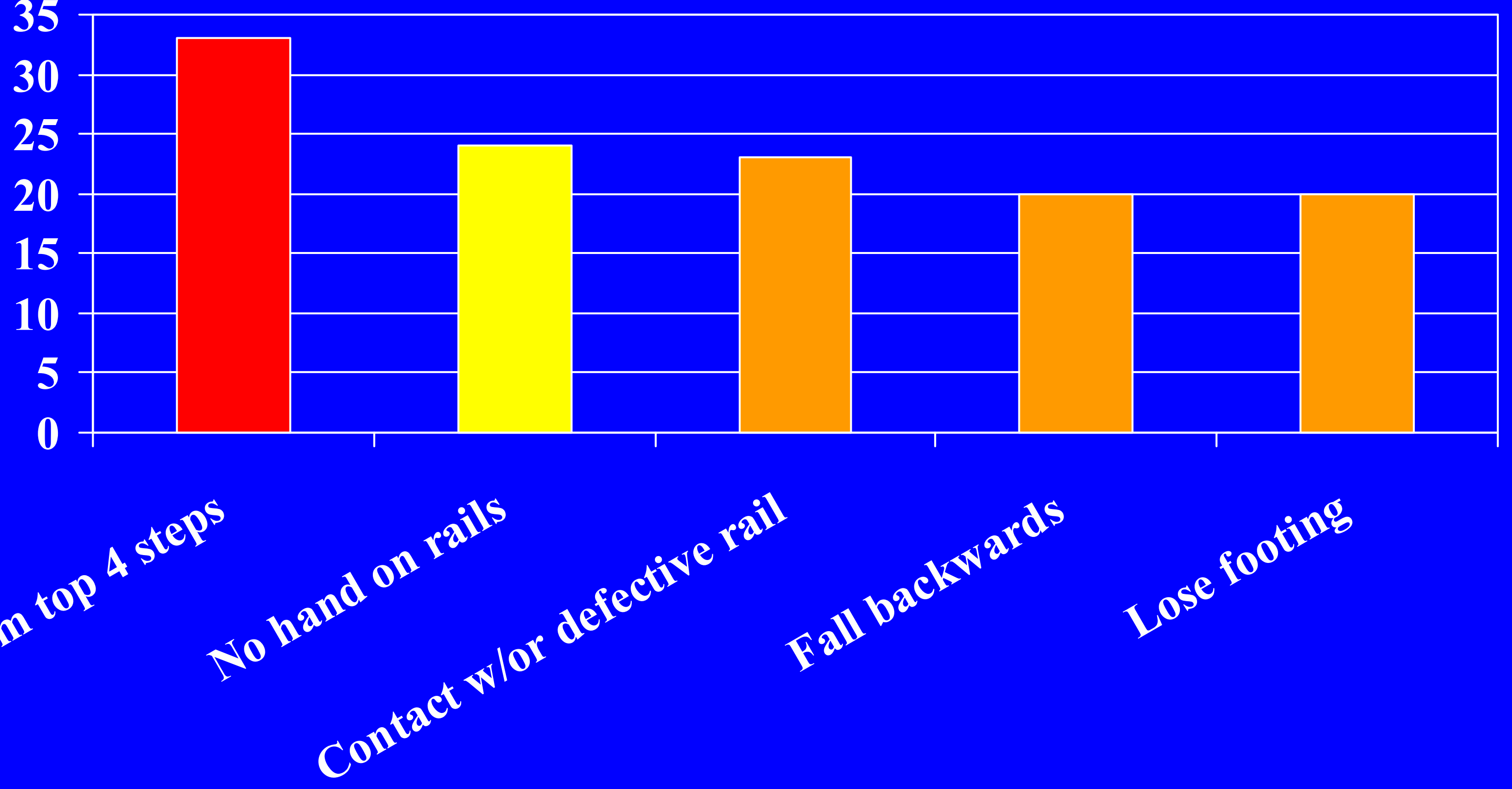
SUMMARY OF FALL MISHAPS ON AIRCRAFT CARRIERS (CVNS)

Ten Years from Naval Safety Center's Data

- 203 fall mishap events with lost time $\geq$5 days
- Almost half these events were falls from ship's ladders.
- Inclined ladders were 60% and vertical ladders 40% of all the ladder mishap events
- Descending inclined ladders occurred the most **(exceeding the sum of all the other categories combined)**.

Number of Falls from Inclined Ladders

Safety Center data from CVNs



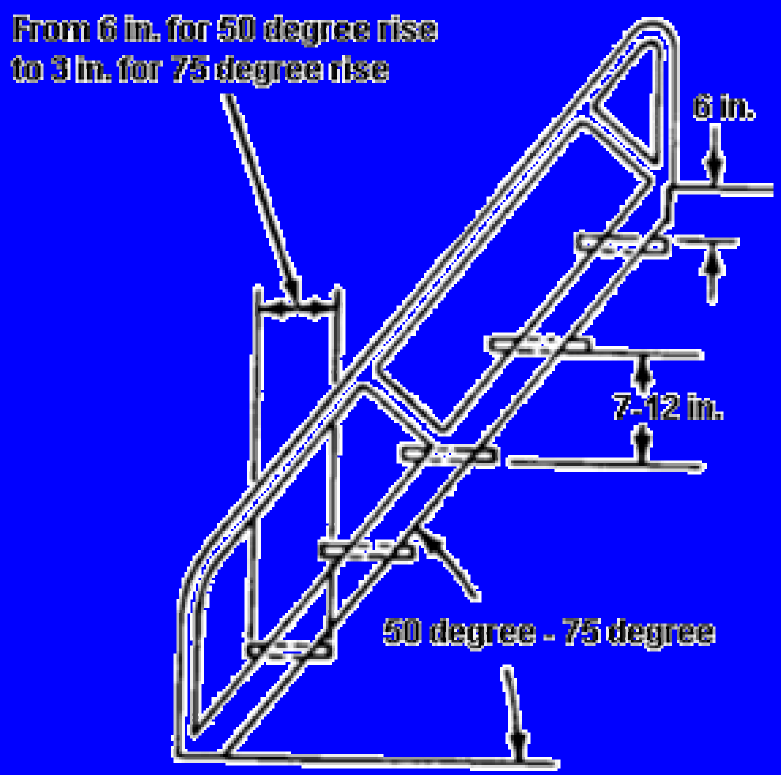
SUMMARY OF FALL MISHAPS TEN YEAR PERIOD ON AIRCRAFT CARRIERS

NAVAL SAFETY CENTER'S DATA

- Descending ships ladders mishaps occurred at a rate 3.5 times those of ascending ladders.
- Backwards falls (heels on ladder tread), while descending inclined ladders at the first four top steps, occurred more than any other fall category.
  - Backward falls generally reported limited or no hand contact with either railings
  - Personnel eventually striking the railing in the course of their falls.
  - Limited tread width contributing to foot slippage.

Design Recommendations for Catwalks, Ladders and Stairs

Figure 3 - Non vertical ladder dimensions. (2)

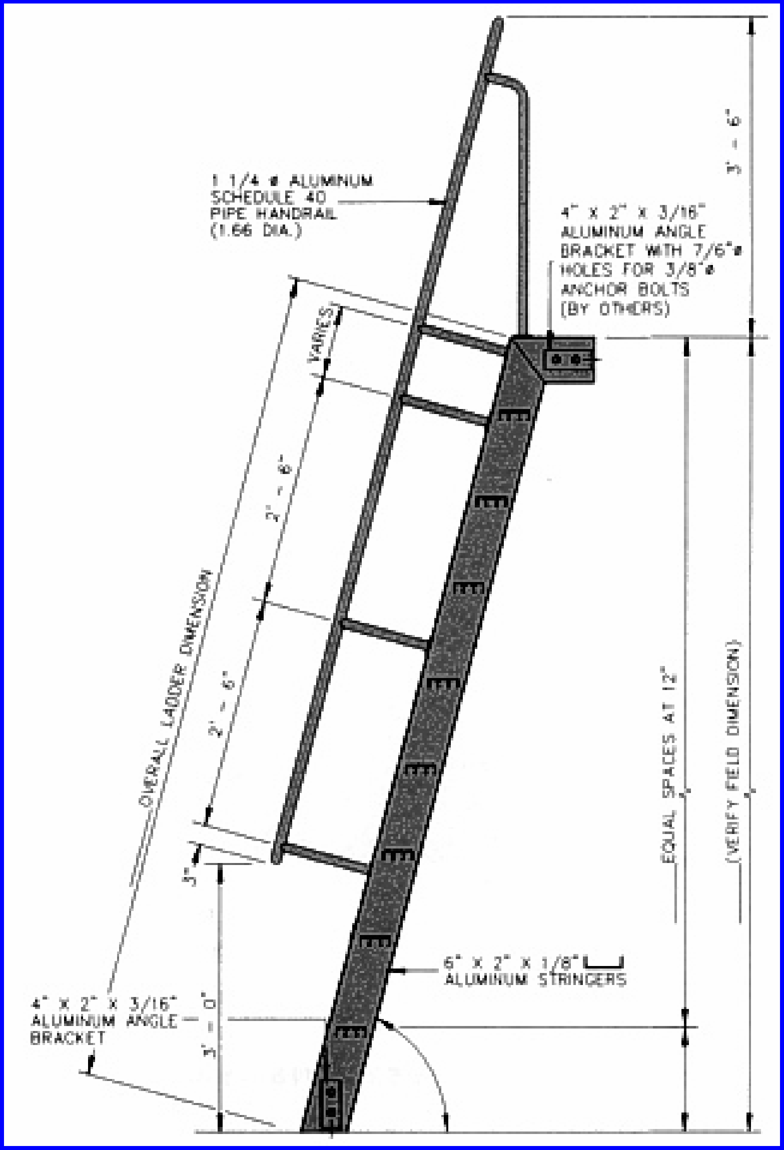


Non Vertical (Stair) Ladders

should have flat horizontal treads (as opposed to round rungs) and two handrails. The most familiar example of this type is the ship's ladder, which usually rises at an angle of 68° from the horizontal (50° - 60° is a preferable range), with a clearance for only one person. Use separate up and down ladders for simultaneous two-way traffic. Two-way ladders should use a maximum tilt angle of 60°, preferably with a double handrail in the center. (2)

http://www.cdc.gov/niosh/pot_wlk2.html

COMMON DESIGN FOR SHIP LADDERS



- **Aluminum Ship Ladders**
- 60 - 75 degree standard angles, other angles and custom designs are available upon request.
- 1-1/2" in diameter pipe rails.
- Available in four models for heavy duty applications.
- All ladders meet or exceed OSHA and ANSI requirements.

RELEVANCE TO OTHER ACQUISITION PROGRAMS AND FALL PROTECTION

- Involvement of interdisciplinary team representing multiple “stakeholders”
- Identification of costs and risks
- Review background data and its limitations
- Evaluation of alternatives
- Specification review with use of ergonomic stds.
- Estimates of cost-avoidance and increased efficiency of alternative approaches
- Persistence

SHIPBOARD WALKING AND WORKING SURFACES

Human Systems Issues

- Efficiency & manpower in materials handling
- Process equipment (elevators, conveyors)
- Maintainability

Safety Concerns

- Lifting injuries (backs)
- Noise from process equipment
- Slips, trips & falls (same level)
- Shipboard ladders
- Fall protection aloft

Other opportunities for human systems integration to reduce risks and lower manpower requirements