UNDERWATER MAINTENANCE AND REPAIR IN LIEU OF DRY DOCKING

USS MIDWAY Museum
Installation of Hull Suction and Discharge Blank Patches
Overview

- Phoenix – Who we are
- In Water Repair Capabilities – The tool kit
  - Hull Cleaning and Inspection
  - U/W Welding
  - U/W NDT (thickness, flaw detection)
  - Cofferdams
  - U/W Painting
- USS MIDWAY Museum – Hull blanking
  - Background
  - Planning
  - Blank Installation Process
- New Technology
- Summary
- Questions

*Underwater Solutions Worldwide*
Phoenix

• Founded in 1997
• Employee Owned
• Specializing in Underwater Services – Engineering, Diving and Remote Operated Vehicles
  ➢ Over 86 Underwater Welding Repairs to Active U.S. Navy Ships and Submarines in the past 5 years
  ➢ Underwater Welding - 32 Underwater Weld Procedures (NAVSEA, ABS and AWS)
  ➢ Inspection and NDT Services

• U.S. Navy Support Services
  ➢ US Navy Diving Services Contract – since 1997
  ➢ Undersea Operations Contract – since 2001
  ➢ Submarine Rescue Maintenance and Operation – since 2006

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U/W I, M & R Benefits

Cost Reduction Over Dry Dock

- No Transit Cost
  - Difficulties of just getting away from the pier
    - Dredging
    - Mooring removal
  - Tugboats
- No Lost Visitor Days
- No Dry Docking Cost – you pay for the work, not the dry dock
- Lower Cost Enables a More Proactive I, M & R Process
- Incremental Process – not all or nothing
  - Phased work based on budget
  - Sequentially address critical need items

Shift Cost of Repair to the Work – Not the dry dock
Getting Started

Contractor Qualifications

- Corporate
  - Quality Management System
  - Safety Program
  - NDT and Welding Procedures and Qualification
  - Flexibility – Cost & Schedule

- Equipment
  - Surface Supplied Diving System
  - Communications and Video
  - Control Van
  - Support Equipment - Welding, cutting, hydraulic tools

- Personnel
  - Commercial Diver training and qualification
  - NDT Qualification
  - Welding Qualification
  - Experience in the task

Avoid SCUBA – mitigate risk

Hire Professionals – Reduce risk of damage or injury
Hull Cleaning - The first step in maintenance and inspection

- **Problem**
  - Excessive growth prevents inspection and hides serious degradation
  - Heavy calcareous growth can lead to coating failure during removal

- **Solution**
  - Periodic removal of marine growth using either multi-brush or handheld machines

- **Benefit**
  - Cleaning process allows a thorough inspection

- **Caution and Concerns**
  - Unqualified operators can severely damage hull coatings

*Hull Cleaning – The key to early problem identification*
U/W Tool Kit

Inspection

- Problem
  - Hull thinning due to corrosion (interior and exterior)
  - Cracks
  - Wasting due to dissimilar metals (weld metal, bronze, brass, stainless steel)

- Solution
  - Visual Inspection (VT) – include color still photographs and video
  - Ultrasonic Inspection Thickness (UTG) – wet or dry localized and large scale mapping of plate thickness
  - Magnetic Particle Inspection (MT) – wet or dry examination of surface indications
  - Ultrasonic Inspection Flaw (UTSW) – wet or dry mapping of indications, detects subsurface cracking

Inspection - First line of defense
U/W Tool Kit

Inspection –

➢ Benefits
  - Locate problems when the fix is minor vs. major
  - Plan and budget repairs well in advance

➢ Caution and Concerns
  - Use qualified Inspectors – American Society of Nondestructive Testing (ASNT)
  - Use experienced Contractor
  - Recognize and separate those areas that need immediate repair from those that are slow to change

Inspection - First line of defense
Typical VT Inspection Photo – Coating Deterioration with Corrosion

*Inspection - First line of defense*
U/W Tool Kit

MT Indication of Cracking

*Inspection - First line of defense*
Underwater Welding – Minor to Major Repair Capability

- Problem
  - Hull plate cracking
  - Corrosion – plate thinning or deteriorated welds
  - Missing hull plate
  - Hull openings not blanked

- Solution
  - Underwater wet welding
  - Underwater dry chamber welding
Wet Welding – Ideal Conditions!

U/W Welding
U/W Tool Kit

Wet Welding
- NAVSEA Approved
  - Process for ships in service
  - Blank installation for deactivation
- ABS Approved
- Permanent or Temporary Repair
- Uses
  - Repair of indications
  - Fillet and Groove welds
  - Installation of doubler plates
  - Installation of blank patches
  - Rudder and Bilge Keel Repair (dewater)
  - Broad range of material compatibility (based on Carbon Equivalent)
    - Carbon Steel electrode
    - High Ni Electrode

U/W Wet Welding – Cost effective repairs
Wet Welding

Benefit
- Relatively low cost
- Easy access to underwater hull and appendages
- Does not require a dry chamber – no fabrication and installation cost

Cautions and Concerns
- Requires use of qualified procedures and welders
  - ABS / AWS / NAVSEA
  - Workmanship
- Requires metal sample analysis for procedure selection
- Interior ship space must be gas free, inert, or flooded
- Minimum visibility requirement – may be a problem in brackish water
- Lower quality weld than dry chamber
- Requires preservation (U/W paint)

U/W Wet Welding – Cost effective repairs
Underwater Welding – Fit Up
Joint Prep

_U/W Wet Welding – Cost effective repairs_

Underwater Welding – Completed Weld
DDG Rudder Repair in a Dry Chamber

_U/W Tool Kit_

_Dry Chamber Welding – Equivalent to dry dock_
U/W Tool Kit

Dry Chamber Welding

- NAVSEA Approved Process for Ships in Service
- ABS Approved Procedures
- Uses
  - Repair of indications
  - Fillet and Groove welds
  - Installation of doubler plates
  - Installation of blank patches
  - Hull plate replacement
  - Rudder and Bilge Keel repair (dewater)
  - Broad range of material compatibly: Mild Steel to HY-80

Dry Chamber Welding – Equivalent to dry dock
U/W Tool Kit

Dry Chamber Welding

- Benefit
  - Repair quality identical to dry dock repair
  - Permanent repair
  - Cost effective compared to dry docking
  - Broad Range of materials

- Cautions and Concerns
  - Requires use of qualified procedures and welders
    - ABS / AWS / NAVSEA
    - Workmanship
  - Requires metal sample analysis for procedure selection
  - Requires engineered, specialized cofferdam – fabrication, rigging, installation
  - Interior space must be gas free / inert
  - Requires preservation (U/W paint)

Dry Chamber Welding – Equivalent to dry dock
Dry Chamber Ready for Installation

Weld Prep in Dry Chamber

Dry Chamber Welding – Equivalent to dry dock

U/W Tool Kit
Dry Chamber Weld – Root Pass with Pre-Heat

Dry Chamber Welding – Equivalent to dry dock
Completed Weld from Interior of Hull

**Dry Chamber Welding – Equivalent to dry dock**
U/W Tool Kit

• Cutting and Burning – Metal Removal
  ➢ Problem
    – Need for removal of metal (plate, stiffeners, appendages) to facilitate repair
  ➢ Solution
    – U/W torch: Exothermic rods, tubular rod
      ▪ Bulk removal of metal
    – U/W Carbon Arc Gouging
      ▪ Weld Preparation
      ▪ Bulk Removal
    – Mechanical Cutting Tools
      ▪ Diamond blade saws
      ▪ Water / Slurry Jets

Cutting and Burning – Fast and efficient
U/W Tool Kit

➢ Benefit
  – Fast, efficient process for weld prep

➢ Cautions and Concerns
  – Requires a very experienced operator
  – Explosive gasses are produced – proper protocol and technique required

Cutting and Burning – Fast and efficient
Cofferdams – Open Top, Side Mount and Overhead

- **Problem**
  - Many repairs cannot be completed in the wet, the area must be dry

- **Solution**
  - Specially designed temporary enclosures for dewatering and access

- **Benefit**
  - Allows topside workers or divers to access a dry work area
  - Broad range of maintenance and repair capability
  - Repair quality identical to dry dock repair - permanent repair
  - Cost effective compared to dry docking

*Cofferdams – A dry environment for work*
Cofferdams

- Cautions and Concerns
  - Requires engineered design and quality fabrication
  - Requires hull template to fabricate seal surface
  - Requires engineered rigging plan
  - May require welding padeyes to the underwater hull
  - Repair area will require preservation (U/W paint)

Cofferdams – A dry environment for work
Surface Piercing Cofferdam Interior

Cofferdams – A dry environment for work

Rigged for Installation

U/W Tool Kit
Cofferdams – A dry environment for work
Overhead Cofferdam – Custom Shape to Suit Task

Cofferdams – A dry environment for work
U/W Fairing & Coatings

- **Problem**
  - Long term preservation and inhibiting corrosion
  - Patching and fairing to restore contour

- **Solution**
  - Wet applied and curing epoxy compounds including thin coatings and thick fairing material
  - Proven technology – decades of use
  - NAVSEA Approved - Hycote, Splash Zone, Belzona ($$)

- **Benefits**
  - Restoration of surface contour
  - Preservation
  - Can be applied to relatively large areas

- **Cautions and Concerns**
  - Surface preparation and application
  - Water temperature limited for cure
Hycote Application

U/W Fairing & Coating Compounds
Maintenance & Repair

Typical U/W Maintenance and Repair Tasks
- Hull Opening Blanking
- Rudder Repair (dewater)
- Rudder Removal
- Propeller Removal
- Hull Plate Insert / Doubler Plates
- Crack Arresting and Repair
- Clad Welding / Surfacing
- Anode Installation
- Impressed Current System Maintenance and Repair
- Painting and Fairing
- Support of Interior Hull Repairs
- Dry Dock Preparation (hull clean, inspection, and work scope)

Full Spectrum of M & R Capabilities
Problem

- Hull Blanks not Installed as required by NSTM CH 050
- 285 Total Openings Requiring Blanking
  - Based on existing docking drawing
  - Detailed survey necessary to ensure no ShipAlt’s added any openings
- Size Range: 5 ft by 12 ft rectangle to 12 inch diameter

Solution

- Phased Repair – 3 year effort
- Hull Cleaning Prior to Blank Installation
- Openings Prioritized Based on:
  - Risk of leakage
  - Location to minimize movement of the dive station

Background
USS Midway Museum
Planning and Preparation

- Pier Space / Lay Down Area Not Available – barge required to support diving operations
- Protected Berth For Barge, but Restricted Access for Movement
- Load Out for Entire Ops – minimal restock during work
- Long Lead Items Ordered /On Hand Prior to Mobilization
- Metal Sample Analysis for Electrode Selection – procedure qualification
- Identify and Prepare Affected Interior Space
  - de-water
  - remove fuel
  - gas free

Background
Dive Station Set Up
- Crane for Handling Blanks
- Dive Gear and Umbilicals
- Welding Machines
- Blanks Painted and Ready to Install
- Small Boat
- Fuel
- Generators / Power
- Fabrication Area
- Cutting and Burning Rig
- Port-a-Johns

**Work Site Layout**
Heavy Fouling and Corrosion in Work Area

Area Prepared to Bare Metal for U/W Coating

**Blank Installation - Preparation**
Blank Fit Up

- QA Check Point – photograph and VT inspection
- Must Match Curvature and Deformity in Hull
- Gap Must Meet Weld Procedure Requirement
- Tack Weld in Place

Blank Installation
Blank Welding

- QA Check Point – Root pass photograph and VT inspection
- Must Meet Workmanship Requirements
Blank Welding

- QA Check Point – photograph, VT & MT inspection

- Must Meet Workmanship Requirements

**Blank Installation – Fill Pass**
Blank Pressure Test

- QA Check Point – de-water and purge with dry Nitrogen: must pass 2 psi over ambient pressure test with 10 minute hold, no leaks or pressure drop

- QA Check Point – final video, vent to surface

Blank Installation – Inspection and test
Blank Installation – Expect the unexpected!
Blank Installation – Expect the unexpected!
USS MIDWAY HULL

Slot Weld 137-2

Box Patch 137

PHOENIX DIVERS
USS MIDWAY (CV 41)
U/W Hull Preservation

Blank Installation – Expect the unexpected!
Blank Installation – Problem solved
Communication

- **Daily Progress Reports**
  - Work completed
  - Work planned
  - Ship’s Force assistance required
  - Problems

- Must be a Team effort to be cost effective
Phase One – All milestones completed!

Statistics
- Phoenix Welders Performed
  - 2,439 hours of bottom time
  - Completed 499 linear feet of 3/8 inch wet welds
  - Installed 35 Hull Blanks
  - Completed 1/3 of total welds required for project completion
  - 1807 sq ft of underwater paint applied

On Schedule and Within Budget
New Technology

Technology to Watch – In water technology lags, but keeps a steady pace with surface capabilities

- NDT and Inspection Tools and Techniques
- Welding Advances
- Coatings and Adhesives
- Cathodic Protection

The Next Generation of Tools
Summary

In Water Repair in lieu of Dry Docking

- Accepted by Major Classification Societies (ABS & DNV)
- Accepted by the U.S. Navy
- Broad Spectrum of Capabilities
- Significant Cost Savings over Dry Docking
  - No towing or ship movement required
  - No lost revenue – open while repairs are being conducted
  - Phase work to fit annual budget
- Not a Cure All – dry docking may be required
  - Pre docking tasks – at considerable savings
    - Full hull clean
    - Thin hull / corrosion survey
    - Removal of damaged plate or components
    - Defined work package – reduce add on work

Underwater I, M & R - An affordable solution
Questions?
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