UNDERWATER SHIP HUSBANDRY (UWSH)

FOR OCEAN-GOING SHIPS

The purpose of this document is to provide guidelines for defining the different tasks associated with the safety considerations, recommended operational guidelines, and training for the conduct of underwater ship husbandry operations for ocean-going ships.

NOTE: These are minimal guidelines. Prior to the commencement of any diving operation, a risk assessment (RA) and job hazard analysis (JHA) shall be completed and all members of the dive team, including the vessel master and chief engineer shall be present at a pre-dive safety meeting. Increased manning levels and additional equipment may be required depending on the scope of the operation.

RESPONSIBILITY

The diving contractor is responsible for ensuring that all components are in place for compliance to these guidelines. They are also responsible for ensuring that personnel have met the proper training, qualification, certification, and medical requirements. It is also the responsibility of the diving contractor to obtain local permits and establish a dive plan that can be tailored to specific ship husbandry operations when necessary. It is recommended that a formal Management of Change (MoC) be performed should any revisions to the dive plan be required.

GENERAL

Ship husbandry entails all aspects of maintenance, cleaning, repair, and general upkeep of the hull, appendages and underwater equipment of a ship (thrusters, rudders, propellers, sea chests, hull plating intakes and discharges), including the repair of pin holes, replacement of anodes, and the welding of cofferdams to isolate cracks.

Underwater ship husbandry includes the following operations:

- Underwater hull cleaning to remove fouling organisms. Such cleaning may be of the entire hull or specific parts, such as propellers, rudders, shafts, thrusters' tunnels, bilge keels, cathodic protection, stabilizer fins and sea chest grating. Pre/post hull inspections should be completed prior to and/or after all underwater work. Hull cleaning may be done by divers using hand-held tools or self-propelled mechanical brushing equipment, water jets or scrapers.
- Non-destructive testing or hull-gaging inspection, including fouling surveys, inspection of known or suspected damage to hulls, appendages, underwater equipment or coatings, and inspection of

previous repairs. Several methods may be used, including visual inspection, video recording, magnetic particle testing and ultrasonic thickness testing.

- Underwater coating is done to repair paintwork/ and epoxies after inspections or repairs, or where small areas of coating have been damaged or have polished through. Suitable underwater paints or underwater epoxies can be applied by the diver using brush/roller or by hand in the case of epoxies.
- Underwater fiberglass wraps can be used for hull repairs or propeller shaft protective coating repair. Repair of fiberglass shaft coating is generally done in a dry habitat mounted over the shaft, allowing access through the open bottom for the divers. The shaft is first cleaned before wrapping with a new layer of sheathing.
- Cathodic Protection replacement, to include sacrificial and/or Impressed Current Cathodic Protection (ICCP) systems.
- Underwater welding is either done in a submerged dry or hyperbaric habitat, or in water. The AWS D3.6M:2010 Underwater Welding Code defines important variables associated with underwater welding (e.g. metal transfer characteristics, solidification behavior, weld appearance, mechanical properties, etc.) and to describe welding and inspection procedures so that work of a known quality level can conveniently be specified. The AWS D3.6 Underwater Welding Standard is currently the only standard available for qualifying wet or hyperbaric underwater welding. Prior to any wet or hyperbaric welding, diving contracts should qualify welder/divers to existing procedures or qualify their own procedures to the class weld that fits their applications.
- Coating damage to the rudder, hull sonar domes and appendages can be repaired by divers. This entails removal of damaged rubber, preparation of the surface and application of rubber patch using a suitable adhesive.
- NDE Inspection of the vessel below the water line, to include general visual survey to specific areas that require hull-gaging/thickness readings or weld seams requiring shear wave inspections.
- Removing obstructions from thrusters, propellers or rudders of the vessel.

NOTE: Several of these operations will release some quantity of harmful material into the water, particularly hull cleaning operations, which will release antifouling toxins. Underwater ship husbandry may cause an adverse environmental effect as significant amounts of copper and zinc are released by underwater hull scrubbing. Alien biofouling organisms may also be released during this process. Environmental regulations regarding the release of these materials vary by location and must be considered as part of the project plan.

Safety in Ship Husbandry

- It is critical that divers understand how ships are constructed and understand the terminology used to describe the various areas and parts of vessels.
- An assessment should be made on the suitability of the vessel from which the ship husbandry diving is taking place. Vessel size, available working deck space, adequate space for equipment and supplies, as well as adequate space to address any diver related emergencies should be considered. Reaction from working next to a large ship in swell and heave, as well as mooring arrangements must also be considered.
- A thorough JHA and RA shall be conducted prior to dive operations.
- All divers' must be established as fit-to-dive before beginning operations.
- A means for the safe recovery of an injured/unconscious diver must be present at the dive site.
- All machinery identified in the JHA/RA that poses a risk to the diver should be adequately controlled using appropriate lockout-tagout (LOTO) and hierarchy of control.
- Diver umbilical management must be outlined to consider all identified hazards.
- There should be adequate umbilical management procedures to restrain divers from accessing live water intakes.
- LOTO warning signs must be posted at the bridge and control room console.

- Ensure LOTO criteria is applied to any diver deployment vessel if utilized.
- All anchor stoppers/chain locks must be engaged.
- Periodic announcements should be made from the vessel's bridge that divers are in the water, and to not take suction from or discharge into the sea, operate propulsion or steering equipment or pay out on moorings or anchors.
- Diver umbilical management must be outlined to take into account all identified hazards.
- Divers should be restricted from transiting further than the keel of the vessel from the side of entry i.e., the side the diver is being tended from.
- Divers' excursion distance should be relative to the diver-worn emergency gas supply and duration at working depth.
- The bridging of the diving contractor's emergency response plan with that of the vessel's emergency response plan should be performed.
- No work may take place above the diver's worksite (no scaffolding, lifting operations, repairs, etc.).
- Assessments should be performed when working on a quayside for other land-based risks such as intakes for seawater, outlets from drains, etc.
- Consideration of differential pressure situations shall be considered where the hull of the vessel is ruptured.
- The Alpha Flag and all other dive-operations warning signs must be displayed as required.
- Periodic updates on weather conditions should be conducted.
- The ship's draft, depth below the hull, and time of tide must be checked. Ensure a safe depth is under the vessel to prevent a diver from being trapped or crushed under the hull during low tides or if the river level drops. Passing ship traffic can turn a "safe" area into a crush hazard area. This can also include the loading and offloading of supplies and materials (or bunkering) while the diver is in the water.
- Make certain the local Coast Guard (or Maritime Authority) and Harbor Master have been notified of any diving operations. Keep a close eye out for vessel traffic and have a method (VHF radio, etc.) to communicate with traffic if necessary. Ensure that known local vessel traffic (yard tugs, etc.) are aware of the operation and have been instructed to maintain a safe distance.
- Consider the proximity of adjacent vessels and whether they require any isolations (dive vessel, etc.).
- Consider whether non-vessel related hazards require isolation – intakes / discharges from the quay and differential hazards (e.g. lock gates / drydock) and other vessels that may be laying alongside or directly forward or aft of the vessel being dived on.
- Consider a dropped-object sweep around the perimeter of the vessel.
- A survey should be performed for fouled propeller or steering gear.
- The use of a downline for saws, scrubbers, and other heavy equipment used for debris removal is recommended.

NOTE: When working off vessels with cracks or suspected leaks, internal pumps need to be stopped to prevent differential pressure injuries to the divers working on the hull of the vessel. All investigations should only take place when the vessel is in port or in calm weather – waves can cause differential pressure on larger cracks.

Lockout-Tagout (LOTO) is a safety procedure which is used in the commercial diving and maritime industry to ensure that potentially hazardous machines (thrusters, intakes, rudders, propellers, ICCS systems) are properly shut off and not able to be started up again prior to the completion of maintenance or repair work. It requires that hazardous energy sources be "isolated and rendered inoperative" before work is started on the equipment in question. The isolated power sources are then locked, and a tag is placed on the lock identifying the designated personnel who placed it. The

diving supervisor then holds the key(s) for the lock, ensuring that only the designated personnel can remove the lock(s) and reenergize the machinery.

Some vessels may be too large or complex for complete isolation. In this case LOTO is performed on segments of the vessel. In this scenario the diver must be physically restrained using a golden gate or similar system to ensure that he does not exit the safe zone. A safety buffer zone of 16.5 feet (5 meters) should be in place to ensure compliance.

NOTE: The ADCI mandates that Lockout-Tagout methods be employed when ship husbandry operations are performed.

- Before diving operations begins on a ship's hull, the diving supervisor should first meet with the master (or mate) and chief engineer and lock out all machinery with intakes, including the main engines. Signed paperwork and possession of keys (by the diving supervisor) for the locks are the only confirmation that lockout procedures have been followed. Depending upon the vessel type, other items that may need to be locked out include (but may not be limited to):
    - Thrusters
    - Steering Pumps
    - Sea Chests
    - Z Drives
    - Pod propulsion systems
    - Impressed current cathodic protection systems
    - HiPAP transducer poles and sonar.
- The main engines and all thrusters must be locked out. If needed, the engineer should be requested to restrain the main shaft from turning if there is a strong current. Additionally, there should be an emphasis on physical restraints on the thrusters to prevent movement caused by strong currents. For steam propulsion plants, turbine gear interlock rotation of the propeller must not exceed 0.2 rpm. Careful planning and special attention must be given during any operation while the propeller is in constant rotation. On large vessels you can isolate the forward half of the vessel and post "GO" – "NO GO" limits and leave the aft available for steering (diving far forward of the midship). Flowing water will cause the propellers to rotate slowly, perhaps entangling the diver. Passing ship traffic can cause a propeller to spin. On smaller vessels, a pipe wrench on the shaft works well. Vessel shafts can also be secured from turning with a chain fall.
    - Lockout-Tagout Compliance MUST have the following five components:
        - Lockout-Tagout Procedures (Documentation)
        - Lockout-Tagout training (for authorized employees and affected employees)
        - Lockout-tagout Policy (Program)
        - Lockout-Tagout Devices and Locks
        - Lockout-Tagout Auditing – Every 12 months, every procedure must be reviewed as well as a review of authorized employees.
- It is important to make certain that no auxiliary equipment on board the vessel is set on automatic start if that equipment has intakes outside of the hull.

DIVE PLAN

The dive plan should be clear and concise. It should adequately cover:

- All pre-job planning and environmental conditions, with the input and approval of the vessel master, chief engineer, and harbor master, as appropriate.
- Any maps, drawings, manuals, or other documents relevant to the dive operation.
- Assignments of responsibility for all personnel during the dive operation.
- Documentation of all required equipment, tools, and materials.
- Diving techniques and tables/schedules to be used.

- Emergency procedures and contacts (First Aid Kit and Emergency O2 Administration Kit
- Detailed outline of the diving operation, to include the dive application utilized.
- Decompression chamber proximity requirement and location.
- Details of the permit-to-work system and the interface between the dive team and the vessel crew, including the means of effecting and controlling isolations of the vessel's systems and machinery that may compromise the safety of the divers and support personnel. Secure isolation of the vessel's machinery needs to be maintained until diving operations have ceased and all divers are confirmed to be clear of the water by the supervisor and termination of the permit-to-work.
- Post-dive operations procedures.
- Safety precautions (access / egress [launch and recovery] of divers to the worksite, including recovery method of an unconscious diver).
- Supervision and coordination with all crane and ROV operations. Restriction on over-side working and lifting operations in the vicinity of diving operations.
- Risk assessment conducted.
- Remoteness of worksite and access to emergency services may require a higher degree of medical competence and equipment to be immediately available at the dive site.
- Recovering an injured/unconscious diver from working depth to a safe place for treatment, and consequential treatment, including possible recompression requires a site-specific plan.
- Plans for conducting emergency drills to test the effectiveness of the emergency plan.
- Readiness verification of life-support and emergency equipment.
- SIMOPS, e.g. surface craft movements, managing general public, neighboring operations.
- Regulation of marine traffic by harbor master/port authority. Cooperation between the dive team and harbor master for the possibility of limiting vessel traffic in the area and when diving in a drydock.
- Any subcontractors or technical authorities providing support or consultation.
- Site Specific Emergency Response Plans must be at the dive location.

MINIMUM PERSONNEL REQUIREMENTS

Because of the wide range of tasks and varying conditions performed as "Ship Husbandry" the minimum manning levels allowed by the ADCI for the mode of diving being performed is an absolute minimum. Dive Team size is subject to formal risk assessment. There must be sufficient number of competent and, where appropriate, qualified personnel to operate all the diving plant and to provide support functions to the dive team. This may require additional support personnel and other management or associated technical support personnel, for example project engineers or maintenance technicians.

The diving supervisor shall be competent for the task and be in possession of a letter of appointment from the diving contractor. A thorough Dive Plan, RA, and JHA needs to be prepared for each project to determine if crew augmentation beyond the minimum allowed levels is needed. Some of the factors that may require additional crew members include the use of tools, heavy current, offshore conditions, size of vessel, remoteness of location, and scope of work. As an example, a relatively simple inspection of a propeller on a small tug, securely fastened to a dock, can typically be performed with a smaller crew than a significant hull cleaning job in an offshore (less protected) environment on a large vessel. Effectively managing an emergency should also factor into determining the size of the dive team.

Should two divers be in the water at the same time, there must still be a surface standby diver available for immediate deployment. A manifold/dive panel to accommodate 3 divers, plus extra

breathing media and treatment gas will be required. Calculations for the specific amounts of breathing media and gas will need to be a part of the pre-job planning.

a. Diving Supervisor

A qualified person shall be designated as the diving supervisor for each diving operation. The diving supervisor oversees the planning and execution of the diving operation, including the responsibility for the safety and health of the dive team.

The diving contractor shall appoint the diving supervisor in writing, and this document must be available at the dive site for review. The diving supervisor should only transfer control of the dive operation to another supervisor appointed in writing by the diving contractor. This transfer of control should be formally documented in the dive log.

In underwater ship husbandry, the supervisor must work closely with the vessel master, officer of the watch, chief engineer, and harbor master. Whereas the supervisor is the only person who can order the start of diving operations, the vessel master or harbor master can tell the supervisor to terminate a dive for safety or operational reasons.

The diving supervisor needs to ensure that all parties are notified that diving operations are about to commence. All necessary permits/permission needs to be in place before commencement of dive operations.

During the dive operation, the diving supervisor needs to have direct verbal communication with the primary and standby diver at all times during the dive operation. Direct communication is also required between the vessel master, chief engineer, or other members of the bridge crew as necessary. This may also include crane operators and ROV pilots.

The diving supervisor shall possess the proper ADCI supervisor certification card (or recognized equivalent) and be knowledgeable and familiar with all techniques, procedures, emergency procedures and operational parameters for the diving mode under his or her direct supervision.

b. Diver / Standby Diver

Must have formal training, experience and industry recognized certification in the following areas:

- Surface-Supplied Air (SSA) diving procedures and techniques.
- Industry recognized certification for the task assigned (diver, supervisor).
- Emergency procedures.
- Diving accident treatment procedures.
- Proper operation and use of all equipment related to SSA diving, including decompression chambers.
- Use of SSA diving equipment
- Familiarity with the type of work engaged in.
- Recognize and report any medical problems or symptoms experienced before, during, and after the dive.
- The standby diver must be in a state of immediate readiness during dive operations. This means donning all necessary equipment for immediate deployment, except for helmets or masks and weight belts.
- Standby divers must be equipped to the same degree/level as the primary diver. The umbilical length of the standby diver must be longer than that of the primary diver(s)' umbilical or be able to reach further because of dive station set-up.

c. Tender/Diver

- Must have the same qualifications as an SSA diver, with the requisite level of experience required.

During the conduct of the job hazard analysis, the diving supervisor must consider whether the use of any surface-tended equipment by the diver will require an additional individual to tend associated cables or hoses, as in the case of hull penetrations, such as ballast tanks, sea chests, tunnel thruster, etc. This includes hand jetting, water blasting, cutting and welding, the use of any pneumatic or hydraulically operated tool, or the use of underwater video or sonar equipment requiring a power or data cable not affixed to the diver's umbilical.
(Personnel on the dive team may carry out more than one duty, so long as it doesn't compromise the safety of the dive team. For example, a diver may assist the supervisor by operating a deck decompression chamber or standing in to help tend another diver.)

OPERATIONAL GUIDELINES

The use of SCUBA is NOT authorized for the performance of Underwater Ship Husbandry Operations.

1. The maximum depth of each dive shall be determined prior to the start of operations.

2. The breathing mixture supplied to the diver must be composed of a mixture of gasses that is appropriate for the depth of the dive. All mixed breathing gasses must be analyzed before they go on-line for O_2 content and for proper mixture necessary to support the maximum depth of the planned dive.

3. A separate dive team member shall continuously tend each diver while the diver is in the water.

4. Diver-worn (or carried) emergency gas supply (EGS) shall be utilized and calculations for the gas supply should be performed based on distance, depth, ingress, and egress of the diver.

5. If no decompression chamber is on site, the nearest manned operational chamber (capable of providing treatment for dive-related illnesses) should be known, and an evacuation plan should be in place. A thorough risk assessment should be conducted to determine if a chamber is needed at the dive site. **Dives with planned decompression and deeper than 100 fsw [30 msw]) are required to have at least one double-lock decompression chamber and adequate air source to recompress the chamber to 165 fsw. An adequate supply of gasses for the planned dive profile and a potential treatment**.

6. Both the diver's umbilical and the hull-cleaning umbilical must be actively tended to ensure the hull cleaning machine does not cut or entangle the diver's umbilical. Risk assessments must be completed for this type of operation. The diver's umbilical and hull-cleaning machine umbilical are not to be mated and must always remain separate from each other.

7. Hull cleaning machines that recover all debris and have large bore recovery pipes pose

a greater challenge for umbilical management. A separate machine operator is to be provided at the power pack control or the dive supervisor must have immediate ability to independently stop the hull cleaning machine's rotating brushes.

8. All machines should have a dead-man handle to allow the diver to immediately stop the rotation of the brushes. The standby diver must be able to respond with the ability to remove the hull cleaning rotating brushes should the diver's umbilical become entangled. **Note: Some machines cannot be moved unless the brushes are moving.**

MINIMUM EQUIPMENT REQUIREMENTS

- One air source to independently support two divers (working diver and standby diver).
- Topside secondary air source.
- Adequate supply of gasses for the planned dive profile.
- Two hose groups consisting of:
  - Air hose.
  - Strength member/strain relief. (The strength member may be the entire hose assembly, if so designed.)
  - Communications cable.
  - Pneumofathometer hose.
- One set of air decompression and treatment tables.
- One control station consisting of:
  - Communication systems.
  - Depth gauges and gas distribution system with the capability to supply and control two divers at the maximum work depth. The rack box/manifold must be equipped with a non-return valve (NRV).
- Two time-keeping devices.
- One basic first aid kit with ADCI required contents. Local regulatory authorities may require additional equipment and training.
- Emergency O_2 administration kit, with sufficient O2 supply for transit to the nearest hyperbaric facility, capable of treating diving-related illnesses.
- Emergency rescue equipment for the recovery of an unconscious/injured diver.
- Two sets of divers' personal diving equipment consisting of:
  - Helmet or mask.
  - Diver-worn EGS.
  - Weight belt if needed.
  - Protective clothing.
  - Tools as required.
  - Safety harness.
  - Knife(s).
- Spare parts, tools, and manuals as required, for the preventive maintenance of equipment.
- Logbooks, dive sheets, safe practices manual, first aid handbook and written JHA applicable to job.

All equipment and personnel must, as a minimum, meet all requirements as contained in the latest edition of the *International Consensus Standards for Commercial Diving and Underwater Operations.*

Further information on diving personnel responsibilities, qualifications and certifications can be found in Section 3.0 of the *International Consensus Standards for Commercial Diving and Underwater Operations.*

Further information on diving modes: definitions, requirements and guidelines can be found in Section 4.0 of the *International Consensus Standards for Commercial Diving and Underwater Operations*.

Further information on underwater operations; procedures, checklists and guidelines can be found in Section 5.0 of the *International Consensus Standards for Commercial Diving and Underwater Operations.*