# International Consensus Standards for Commercial Diving and Underwater Operations

6.5 EDITION

Association of Diving Contractors International

# INTERNATIONAL CONSENSUS STANDARDS FOR COMMERCIAL DIVING AND UNDERWATER OPERATIONS

**6.5 EDITION**

**ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.**
**Safety • Education • Communication**

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# The Mission of the ADCI is:

- **To promote the highest possible level of safety in the practice of commercial diving and underwater operations.**
- **To promote proper and adequate training and education for industry personnel.**
- **To foster open communication within the underwater industry.**
- **To hold all members accountable in adherence to the International Consensus Standards for Commercial Diving and Underwater Operations.**

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# RECORD OF CHANGES

**Gap Analysis Between Edition 6.4 and 6.5**

**Changes to edition 6.5 (23JAN2025)**

## SECTION 1 GENERAL PROVISIONS

Renumbering of pages

## SECTION 2 DIVING PERSONNEL MEDICAL AND TRAINING REQUIREMENTS

### 2.3 DIVER MEDICAL REQUIREMENTS

New revised medical section

## SECTION 3 DIVING PERSONNEL RESPONSIBILITIES, QUALIFICATIONS AND CERTIFICATIONS

### 3.1.4 CERTIFICATION AND TRAINING MATRIX

Removal of the International Endorsement Certification Matrix from underneath the title "CERTIFICATION AND TRAINING MATRIX.

Add minimum requirement for dive school instructors that oversee the practical diving exercises to hold an ADCI SSA Supervisor certification. The instructor(s) that teaches the mixed gas ($HeO_2$) practical training is required to possess an ADCI $HeO_2$ Supervisor certification.

Add ROV certification and curriculum to ROV section (Section 9).

### 3.1.5 DOCUMENTATION ACCEPTED:

5. Non-ADCI Member Commercial or Government/Military Diving Schools:

**"The ADCI reserves the right to reject any applications for certification if it cannot be confirmed that the training program/school complies/adheres to the standards outlined in the International Consensus Standards for Commercial Diving and Underwater Operations."**

### 3.1.8 PHOTO INSTRUCTIONS FOR COMMERCIAL DIVER AND ROV PILOT CERTIFICATION CARDS

Add to the front and back of certification card.

### 3.1.9 APPLICATIONS

Add application for ROV Pilot.

## SECTION 4 DIVING MODES: DEFINITIONS, REQUIREMENTS AND GUIDELINES

### 4.2. SELF-CONTAINED UNDERWATER BREATHING APPARATUS (SCUBA)

Add new and revised subsection

### 4.0 GENERAL INTRODUCTION

**All equipment and personnel levels referenced in Section 4 should be considered the recommended minimum for approaching ALL diving applications, which is based on one dive and any applicable decompression required. Increased personnel levels and additional equipment may be required for any diving of more than one dive and any decompression required. Proper pre-job planning shall be conducted to ensure the necessary levels of personnel and equipment are available for diving operations. Additionally, all hazards shall be reviewed onsite, and appropriate changes made accordingly.**

Specific operations procedures vary with the type of diving mode employed. A project risk assessment/hazard identification process or dive plan shall be performed prior to mobilization to determine the type of diving mode to be employed, the equipment needed, and the job personnel requirements.

Before the commencement of any diving operation, the job hazard analysis shall be reviewed onsite with mitigations enhanced if conditions warrant. All dive team members, including the master of the vessel (as well as other involved personnel), shall be present at a pre-dive safety meeting.

## 4.1 SELF-CONTAINED DIVING (SCUBA)

SCUBA is an acronym for self-contained underwater breathing apparatus. Commercial SCUBA divers carry two sources of air (primary and emergency reserve) that allow underwater breathing. Many underwater inspections require using SCUBA equipment to access remote target work areas where a surface-supplied diving system would be impossible or dangerous. This section outlines the personnel requirements, limits, and procedures related to commercial SCUBA diving.

SCUBA procedures should not be used for commercial diving operations except where they can be shown to be equally as safe or safer than surface-supplied air diving. The following are the minimum requirements for Commercial self-contained diving operations.

Recreational SCUBA diving courses at any level do not provide adequate training, nor are they recognized as commercial diving training. Therefore, each dive team member conducting Commercial SCUBA dives is required to have an ADCI certification card.

### 4.1.1 MINIMUM PERSONNEL REQUIREMENTS

The minimum number of personnel comprising a SCUBA dive team is never less than four. However, planning must consider not only the direct requirements of the work to be performed but also additional known or suspected factors that may lead to complications during the conduct of the intended operation. Merely because a dive team comprised of four persons may be adequate during one operation does not mean the same number of persons will be enough to accommodate the requirements of a different operation.

Commercial tethered SCUBA Diving 0-100 fsw (0-30 m) with no decompression:

- One diving supervisor
- One diver line tethered to the surface with communications
- One tethered standby diver with communications shall be properly equipped and capable of performing the duties of a standby diver
- One tender
- All members of the team on the surface must be qualified first aid, CPR, and O2 providers or Diving Medical Technicians (DMT)

Commercial untethered SCUBA Diving 0-100 fsw (0-30 m) with no decompression:

- One diving supervisor
- Two divers
- One tethered standby diver with coms shall be properly equipped and capable of performing the duties of a standby diver
- All members of the dive team on the surface must be qualified first aid, CPR, and O2 providers or Diving Medical Technicians (DMT)

**NOTE:** *Any deviation from the personnel requirements requires a change to the dive plan, and the JSA/HAS must be reviewed for possible changes.*

### 4.1.2 OPERATIONAL GUIDELINES

Minimum Operating Requirements (SCUBA Imperatives)

1.SCUBA dives shall not be conducted against currents exceeding one (1) knot or 1.6 ft. per second.

2.SCUBA dive depths shall not exceed 100 fsw (30 msw) or no-decompression limits.

3.The planned time of a SCUBA diving operation shall not exceed the no decompression limits or the limits of the diver's planned air supply duration.

- Emergency gas supply (bailout) shall always have a minimum calculated Five-minute supply at the planned deepest depth of the dive.

4.SCUBA divers shall be equipped with a diver-carried primary and emergency air supply routed through a switch/manifold block.

5.Cylinder (primary and emergency) pressure shall be determined immediately before each dive.

- Both sources shall be equipped with separate submersible pressure gauges.
- When diving without a reserve, the dive shall be terminated when the cylinder pressure reaches 500 psi for a single cylinder or 250 PSI for twin cylinders.

6.SCUBA divers shall have voice communications between each other and the surface at all times.

7.SCUBA penetration dives are strictly prohibited. SCUBA shall not be conducted in enclosed or physically confining spaces or where the diver does not have direct surface access.

8.SCUBA dives shall not be conducted in areas where pressure differentials exist or are suspected.

9.During all SCUBA dives, a tethered standby diver with coms shall be available while a diver(s) is in the water.

10. SCUBA divers shall be line-tended from the surface or accompanied by another diver in the water in continuous visual or physical contact during the diving operations.

11. Diving on SCUBA shall only be allowed during daylight hours.

12. All divers on SCUBA shall wear a buoyancy compensator that provides a maximum of 10 lbs of positive buoyancy at the maximum depth, a power inflation source, and an oral inflation source. Divers shall be equipped with a whistle or other audio signaling devices.

13. The diver shall also carry a lighted beacon during low or poor surface visibility circumstances.

14.Tools powered by hydraulics, air, or batteries shall not be used while conducting commercial SCUBA diving.

15.Inspection instruments such as cathodic protection probes and ultrasonic thickness meters are allowed.

16.Nitrox diving is only permitted when a recompression chamber is on site. The entire team is properly trained and equipped for Nitrox diving. The diving supervisor must have the ADCI Nitrox endorsement.

17.Commercial SCUBA is strictly prohibited on an active construction site.

Diver-worn/carried emergency gas supply (bailout) must have a minimum calculated five-minute supply at the anticipated depth.

### 4.1.3 MINIMUM EQUIPMENT REQUIREMENTS

1.Each diver shall be equipped with a knife, diving watch, and depth gauge.

2.A buoyancy compensator device (BCD) providing a minimum of 10 lbs buoyancy at maximum depth with a power inflator and oral inflator.

3.Divers shall be equipped with a whistle or other audio signaling devices.

4.Two cylinders that meet the air consumption requirements for the planned dive and one of which has a minimum five-minute air supply at the planned deepest depth of the dive

5.Two first-stage regulators (primary and emergency)

- Each regulator shall have an over-pressure relief valve.
- The primary regulator shall have an inflator whip connected to BCD and a dry suit if applicable.
- Each regulator shall be equipped with a separate submersible pressure gauge.

6.Each diver will be equipped with a Gas switching/manifold block.

7.Full-face masks with either

- Through water communication to the surface (supervisor), with diver-to-diver communications.
- Tethered Communications to surface (supervisor)

8.A weight belt with a quick release or a BCD with integrated detachable weights appropriate for the suit and depth of the dive shall be worn.

9.An emergency $O_2$ administration kit and an approved ADCI first aid kit. (Readily available for the treatment of diver{s}).

### 4.3 SURFACE-SUPPLIED AIR DIVING

Add in bold and shaded box:

"When two divers are working simultaneously from a single dive station, an additional standby diver and topside tender are required."

### 4.3.1 MINIMUM PERSONNEL REQUIREMENTS

Add to 4th bullet: "All personnel on the dive team must possess current first aid / CPR certifications, as well as O2 provider training."

### 4.2.2.1 MINIMUM PERSONNEL REQUIREMENTS

Add to 5th bullet: "All personnel on the dive team must possess current first aid / CPR certifications, as well as O2 provider training."

### 4.3.3.1 MINIMUM PERSONNEL

Add to 5th bullet: "All personnel on the dive team must possess current first aid / CPR certifications, as well as O2 provider training."

### 4.4 ENRICHED AIR DIVING (NITROX)

Add in bold shaded box:

"When two divers are working simultaneously from a single dive station, and additional standby diver and topside tender are required."

### 4.5 SURFACE-SUPPLIED MIXED GAS DIVING (HEO2)

Add in bold shaded box:

"When two divers are working simultaneously from a single dive station, and additional standby diver and topside tender are required."

### 4.5.1 MINIMUM PERSONNEL REQUIREMENTS

Add to 5th bullet: "All personnel on the dive team must possess current first aid / CPR certifications, as well as O2 provider training."

### 4.6 MINIMUM PERSONNEL REQUIREMENTS

Add a 7th bullet: "All personnel on the dive team must possess current first aid / CPR certifications, as well as O2 provider training."

## SECTION 5.0 UNDERWATER OPERATIONS: PROCEDURES, CHECKLISTS AND GUIDELINES

### 5.2 EMERGENCY AID

3.

o Change the first bullet to read: "Decompression chamber to accommodate U.S. Navy Treatment Table 6."

o Change the fourth bullet to read: "On-call physician that is knowledgeable of the type of diving operation conducted to treat for potential diving-related illness."

### 5.6 STANDBY DIVER REQUIREMENT

Add 3rd paragraph to read: "If there are two or more divers in the water, there is still a requirement for a topside standby diver and tender. All divers must be actively hand-tended by a member of the dive team."

### 5.30 WELDING AND BURNING

Add to 2nd bullet: "Welding machines that can be switched to supply AC power are not recommended."

Add in bold and shaded box: "While in the saturation diving mode, no gases created during the venting/burning/welding process can be allowed to enter the diving bell. This can contaminate the atmosphere of the diving bell. Close attention should be paid to current and tide shifts."

# SECTION 6 LIFE SUPPORT EQUIPMENT: REQUIREMENTS, MAINTENANCE AND TESTING

## 6.4.4 CLOSED-CIRCUIT AND GAS RECLAIM HELMETS

Change item 1 to read: "Meet general requirements of Section 6.4.1."

## 6.5.1 GENERAL (I.E., ALL HOSES ASSOCIATED WITH THE BREATHING GAS SYSTEM)

Add to 7: "It is recommended that all hoses be flushed annually for the removal of any potential contaminants."

## 6.6.4 AIR PURITY REQUIREMENTS

Add to 1: "For breathing air obtained from a third-party supplier, contractors and schools should obtain a copy of the air purity test performed and have it available for review upon request."

Revise 2 to read: "At a minimum, all air purity tests are to be taken at the point of discharge, from either low-pressure (LP) and/or high-pressure (HP) compressors, transfer pumps, or booster pumps."

## 6.7 MANIFOLDS

7. Shall have pneumo gauges rated at1/2 of 1% accuracy or greater as needed for the job intended.

## 6.8 PRESSURE-REDUCING REGULATORS

(3) Pressure-reducing regulators should be set at MAWP (or lower) and must not crack at more than +10% of the MAWP.

## 6.9.1 LAUNCH AND RECOVERY SYSTEMS (LARS)

Remove item 2.

### 6.11 GAUGES

1. Be suitable for purpose intended.
2. Be cleaned for oxygen when installed in oxygen systems using mixtures greater than 50%.
3. When used to indicate a diver's depth:
   - o Be of appropriate range and graduation.
   - o Graduated in units consistent with the decompression tables to be utilized.
   - o Calibrated to a known standard every six months.
   - o Tested for accuracy in accordance with ASME B4-100-2005. Gauges must be tested at a minimum of 5 points, ascending and descending the full scale with a variance no greater than the accuracy of the gauge as stated by the gauge manufacturer. Test points must be spread over the full range of the gauge and include points within 10% of the ends of the dial so as not to "pin" the gauge.

**Examples**:

.50% accuracy of full scale:

0-300 fsw gauge would have +/- 1.5 fsw tolerance at any given test point.

.25% accuracy of full scale:

0-300 fsw gauge would have +/- .75 fsw tolerance at any given test point.

0-1200 fsw gauge would have +/- 3.00 fsw tolerance at any given test point.

Be marked with a label, tag or sticker indicating date of last calibration, due date, and technician's initials, which will not interfere with full scale visibility.

Have calibrations documented in the equipment log.

A pressure-limiting device may be fitted to avoid gauges from being over pressurized.

Be of appropriate range and graduation and rated at minimum .50% full scale accuracy for gauges 0-300 fsw or less and minimum .25% full scall accuracy for gauges greater than 0-300 fsw or greater as needed for the job intended.

4. Master reference test gauge used for calibration should have an accuracy of at least 4X better than the accuracy of the gauge being tested must have a minimum accuracy of .25%. Master test gauge must be tested for accuracy annually if permanently installed. If not permanently installed, testing is required bi-annually.

5. Discrepancy – Be recalibrated when a discrepancy exists exceeding 2% of full scale.

### 6.13.1 VOLUME TANKS AND AIR RECEIVERS

Add to 10: "It is recommended that volume tanks and air receivers be flushed annually for the removal of contaminants."

### 6.14 PRESSURE VESSELS FOR HUMAN OCCUPANCY (PVHO)

Viewports need to be changed out every ten (10) years as required by ASME PVHO (with appropriate documentation)."

## SECTION 7 EMERGENCY PROCEDURES, ASSESSMENTS AND REPORTING OF ACCIDENTS

### 7.2.1 ACCIDENT REPORTING FORM

Remove, and replace with new Casualty and Compliance Report

## SECTION 9 REMOTE OPERATED VEHICLES (ROV)

New and revised ROV subsection (Curriculum and certification requirements).

## SECTION 10 AUDIT COMPLIANCE PROCEDURES

This has been removed from the standard. All ADCI Audit Reports are now standalone documents.

## SECTION 11 REFERENCE MATERIALS

Removal from Section 11 (reference documents):

- oANSI/ACDE-01-2015
- oUSCG 46 CFR Part 197 Subpart B
- oOSHA 29 CFR Part 1910 Subpart T

Add Guidelines for Delta P Diving in Power-Generating Facilities.

# SECTION 1.0

# GENERAL PROVISIONS

Association of Diving Contractors International, Inc.

# 1.0 GENERAL PROVISIONS

## 1.1 SCOPE AND APPLICATION

### 1.1.1 PURPOSE

The purpose of these consensus standards is to provide best industry practices in a clear and complete format in order to contribute to the safety and well-being of all those working in the commercial diving industry, especially commercial divers, tenders, deck support personnel and supervisors.

These consensus standards apply to all types of underwater work, whether inland or offshore, involving commercial diving. It is intended that these standards will complement applicable government rules and regulations as well as supplement industrial codes of safe practice for diving and underwater operations by providing a consensus of industry best practices for underwater diving operations.

Nothing contained in this manual shall be construed to take the place of any law, rule or regulation of any governmental agency.

### 1.1.2 PRESERVATIVE ACTS

These consensus standards represent the generally applicable standards that apply to normal or typical situations. The ADCI recognizes that variations from these standards may be needed and appropriate where emergency and unanticipated situations arise.

# ADCI 2018 STANDARDS

The Association of Diving Contractors International, Inc. (ADCI), hereby recognizes and endorses this standard as one being acceptable for an entry-level remotely operated vehicle (ROV) pilot-technician.

The Association of Diving Contractors International, Inc. requires that an entry-level ROV pilot technician at work must have received adequate training to safely undertake the work involved in the ROV operation. As part of this requirement, each ROV pilot-technician must possess a valid certificate of training. This may be:

- A certificate of training issued by an Association of Diving Contractors International, Inc accredited school; or
- Commercial ROV experience or combination of both commercial experience and training; or
- The equivalent of the training requirements as outlined in the ADCI standard.

## COMPETENCE ASSESSMENT

Beginning in 2017, in its endeavor to foster better vocational training and education, the Association of Diving Contractors International, Inc (ADCI) encouraged the development of standards-based qualifications that focused on essential competence at the workplace and that was assessable, as well as understood, by employers, trainees and trainers.

With the agreement of the industry, ADCI decided in 2018 that such an approach was appropriate to ROV pilot qualification and that certificates should be issued on the basis of competence rather than merely the completion of a training course. ADCI subsequently developed the competence standard and related assessment requirements as set out in this document.

Competence is determined through written tests, instructor evaluation, log book records, and the trainee's performance, attitude, and ability to conduct in-water ROY-related work tasks. In conjunction with an ROV training course, ROV pilot-technicians will be assessed by schools that have been accredited for this purpose. Theoretical competence forms the foundation for the application and is required when practical ability and skills depend on some element of knowledge and understanding. Where both theory and practice are indicated, pilot-technicians will be assessed both ways. Assessment records on each trainee will be maintained by individual training sites.

Although not spelled out as a specific competence, all pilot-technicians recommended for a certificate shall have achieved specified in-water times during training and assessment. Those times for training are set out in the published Entry Level ROV Pilot-Technician Training Minimum Standard and are further clarified in the standard where needed to avoid ambiguity.

To obtain a certificate of training, a student shall achieve a minimum of 228 hours of formal instruction.

## COMPETENCE STANDARD

This new standard was derived from a comprehensive survey of industry requirements for both the onshore and offshore environments and reflects the diverse operational scenarios that employ ROV operators. This standard is comprehensive in nature and specifies minimum requirements for demonstrating competency.

The competence standard represents abilities that a ROV pilot-technician must demonstrate under testing before he or she can be issued an entry-level ROV pilot-technician certificate. This standard pertains whether the certificate is the result of training or experience, or both.

The competence standard is divided into sections that represent important aspects of a ROV pilot-technician's ability and can be identified as such by employers. These include, for example, complete ROV operational scenarios - the ability of the ROV pilot-technician to operate within a team to safely mobilize a system, perform basic calibration and troubleshooting, deploy the ROV system, dive the ROV underwater to the work site until the job is finished or the pilot time is up, return safely to the surface, and safely recover the ROV from the water and perform necessary post dive checks. Each section is further divided into main headings and subheadings. The latter provides the essential details on which the pilot-technician will be assessed.

The aim of the standard is to:

- Improve the quality of training, with both theoretical and practical applications, for entrants to ROV operations.
- Reduce the risk of accidents attributable to inadequate training.
- Establish consistent minimum training requirements to insure continuity of training within the ADCI.
- Require that graduates be qualified and competent to dive an appropriate ROV and perform underwater work assignments before receiving a certificate.

This standard was developed to establish what is to be taught, the minimum length of training required for each section, the minimum qualifications for instructors, and the minimum facilities and equipment required to support that training. In developing this standard, subject matter that is similar, or closely related, is grouped together. Subject matter been further subdivided into topics of manageable size for instructional purposes and detailed lesson planning. Such grouping is not intended as a training schedule.

After the effective date of the standard, the (ADCI) hereby recognizes and endorses this standard as the acceptable minimum training standard for the entry level ROV pilot-technician. All ROV pilots who can document an equivalent level of training through a combination of field experience and/ or formal diver training prior to the original issue date (2018) are specifically exempt from its application.

ADCI provides accreditation to all of its member schools and ensures that a national system of ROV pilot-technician training is maintained. ROV pilot-technician training institutions wishing to become a member of ADCI are inspected and evaluated to ensure their training standards provide training for entry level ROV pilot-technicians at the level of this standard.

Questions regarding this standard and/or applications for membership in ADCI should be addressed to:

ADCI ROV Training Competency Assessment

Deviation from the standard may be made only to exceed or supplement the required training.

The order of sections presented by ADCI for training requirements is not restricted to the section sequence contained herein. Differences in facilities, equipment, local administrative requirements, state and federal laws and/or similar conditions may warrant modification of any established sequence. It is the responsibility of each school to provide for the efficient implementation and administration of this standard and to ensure that each topic presented herein is presented in a way that provides a maximum gain in knowledge and skill for each trainee. The minimum standard will be reviewed periodically to reflect changes in technology, techniques and other developments that are likely to occur in the commercial diving industry.

## ENTRY LEVEL ROV PILOT-TECHNICIAN MINIMUM STANDARDS

### 1.1 GENERAL REQUIREMENTS

### 1.1.1 FACILITIES

Training facilities shall meet all federal, state and local requirements and laws. They should possess adequate space, equipment and safety regulations to offer safe and competent training. Aside from federal, state and local requirements, at a minimum, facilities will include classrooms with adequate lighting, tables, desks, seating, blackboards/whiteboards, audio-visual equipment, technical library, texts and training materials to support the student learning environment. Training facilities must be available to support practical, in- water training including shore based and vessel based operations, etc.

### 1.1.2 STAFF

Each training facility should have adequate support staff to maintain high-quality teaching standards, facility, equipment, records and emergency procedures. Staff members should be selected for their competency in performing their assigned tasks.

### 1.1.3 INSTRUCTORS

Schools should employ instructors with a minimum of two years of full-time working experience in related ROV operations, or area of instruction taught, and should meet state educational requirements for vocational instructors. If required, instructors must meet state and/or city codes. All instructors should be trained in emergency policies and procedures.

### 1. 1 .4 EQUIPMENT

All ROV and support equipment will be properly maintained in accordance with manufacturer's specifications.

Practical training (hands-on) should be conducted with equipment that the trainee will use in the industry. Knowledge of newly developed equipment should be taught. Manufacturer's operational manuals must be available, as well as instruction manuals, equipment and tools for hands-on repair and maintenance. This must be in addition to equipment used for in-water operations.

All ROV pilot/technician training facilities will provide, at a minimum, at least two different types of operational ROV systems common to the industry as outlined in section 9 .2.1 - vehicle classification. One of these operational ROV's must be an observation class vehicle (Class II) or higher. ROV systems that are not dive ready or fully operational can also be used for training but cannot be included in the minimum operational ROV requirement.

Other ROV and support equipment that must be provided on site as part of the training program includes, but is not limited to, the following:

Schools should employ instructors with a minimum of two years of full-time working experience in related ROV operations, or area of instruction taught, and should meet state educational requirements for vocational instructors. If required, instructors must meet state and/or city codes. All instructors should be trained in emergency policies and procedures.

a. Electronic/electrical diagnostic equipment including:

- Digital multimeters
- Meggers
- Oscilloscopes
- Power supplies
- Soldering equipment
- Spare copper tether

b. Optical diagnostics equipment including:

- OTDR
- Power meters
- Fusion and hot melt splicing equipment
- Spare fiber

c. Acoustic locators and sonar devices including:

- USBL or LBL type system
- ROV integrated sonar system

d. Hydraulic/fluid power equipment including:

- Mechanical or electromechanical hydraulic circuit trainers
- Hydraulic hose construction systems
- Flow and pressure meters

e. Cranes and other lifting devices

f. Rigging equipment common to the ROV industry

### 1.1.5 TRAINING AIDS

Books and training aids should contain current information and be appropriate for individual courses and modules. Up-to-date audiovisual aids should be used with all applicable instruction. Students should be supplied with ADCI ROV pilot log book., which must be maintained and updated on a regular basis.

### 1.2 PHYSICAL FITNESS

The importance of physical fitness will be emphasized to students throughout the training program.

### 1.3 INDUSTRY INPUT

Close liaison with the safety, education and medical committees of the ADCI should be maintained to ensure that training meets industry requirements and needs. Contact with the commercial ROV companies and equipment manufacturers should be maintained to ensure awareness of changes and improvements in equipment, procedures, safety requirements, etc.

### 1.4 EMPLOYMENT

Students shall be informed about employers' hiring policies regarding drugs and alcohol. Responsibilities of ROV pilots shall be included in the training. Rules and regulations for the United States Coast Guard, Association of Diving Contractors (ADC) Consensus Standards and OSHA shall be an integral part of the training.

### 1.5 SAFETY

Safety and compliance with federal, state and ADC standards should be emphasized throughout the training program. Students will be instructed that the basic responsibility for both personal and operational safety lies with each individual.

### 1.6 DOCUMENTATION

Documentation of all training successfully completed must be available to the student, including transcripts, diplomas, and certificates. Students will be issued and required to maintain an official ADCI logbook. Upon completion of training, an official ADCI certification card will be issued to each graduating student.

### 1.7 DRUG POLICY

Safety is of paramount importance. ADCI is committed to maintaining a safe, healthy work and training environment and is dedicated to providing a drug- and alcohol-free workplace.

A substance abuse policy should be strictly enforced. This will provide a means to minimize the use of intoxicants by personnel, staff, employees and trainees, and will enhance safe conduct of operations. The goals should be to attain the highest work and training standards possible and to promote a safe work environment, free of drugs and alcohol.

The goals and objectives of maintaining safety in a drug-free work environment are attainable through cooperation at every level and by explicitly and forcefully prohibiting the use, manufacture, distribution, dispensation and possession of illicit drugs, drug paraphernalia and alcohol at all training locations and diving operations.

# SECTION 2.0

# DIVING PERSONNEL MEDICAL AND TRAINING REQUIREMENTS

Association of Diving Contractors International, Inc.

## 2.1 GENERAL

Each person engaged in diving and underwater operations shall possess the necessary qualifications for the job assignment. Designation of skill levels in these standards incorporates three primary elements:

- Technical training
- Field experience
- Demonstrated proficiency

Persons assigned to specific diving and underwater activities shall possess the following:

1. Knowledge and skills gained through a combination of formal training and/or experience in the following:
   - All dive crew members must undergo an annual diving physical. The physician can use his/her discretion on those dive crew members who will not be exposed to hyperbaric conditions (i.e, Non-Diving Supervisors).
   - Diving procedures and techniques.
   - Emergency procedures.
   - Physiology and physics as they relate to diving.
   - Diving equipment.
   - First aid and CPR.
2. Familiarity with procedures and proficiency in the use of tools, equipment, devices and systems associated with the assigned tasks.
3. For persons engaged as divers or otherwise exposed to hyperbaric conditions, physical qualifications for such activities must be met as outlined in **Section 2.3 Diver Medical Requirements.** Such physical qualifications must be documented on an ADCI **medical history and physical examination form,** or an equivalent form.
4. For persons who operate decompression chambers, knowledge and experience with chamber operations.

**A person lacking the required experience and proficiency outlined above may be assigned a task, under the direction of an experienced and qualified individual, in order to obtain the experience and level of proficiency required.**

**Personnel trained and certified by recreational agencies such as, but not limited to, the National Association of Underwater Instructors (NAUI), the Professional Association of Diving Instructors (PADI), the Young Men's Christian Association (YMCA) or other such organizations are not sufficiently well-trained to participate in or conduct commercial diving activities without additional formal training from an accredited source.**

**For contractors operating in the United States, OSHA considers an employer to be in compliance with the diver training requirements of the Code of Federal Regulations for any employed diver with a valid ADCI Commercial Diver Certification Card for the appropriate training level.**

## 2.2 COMMERCIAL DIVING TRAINING REQUIREMENTS

### 2.2.1 ENTRY-LEVEL QUALIFICATIONS

All personnel entering the profession of commercial diving shall be a high school graduate or equivalent. The entry-level minimum skill designation on the diving crew is a tender/diver. The entry-level tender/diver satisfies the minimum entry-level qualifications of diving proficiency, technical proficiency and experience by successfully completing a formal course of study.

A formal course of study for a tender/diver shall be completed at any accredited school, military school or equivalent whose curriculum, at a minimum, conforms to ANSI/ACDE-01-2015.[2] This standard can be found in the reference section.

The ADCI recognizes some formal training certificates issued from within other nations. Certificates of that nature will be evaluated together with presented documentation such as dive logs/supervisor logs, etc., to determine whether the individual is eligible in all respects for issuance of an ADCI commercial diver card.

The ADCI does not perform as an educational organization and as such does not endorse, certify or accredit any school participating in the training of personnel. Member schools are expected to obtain and preserve appropriate accreditation from agencies under whose jurisdiction their educational requirements must be maintained.

### 2.2.2 MINIMUM REQUIRED EXPERIENCE AND PROFICIENCY

1. Advancement beyond the designation of tender/diver requires completion of actual participation in commercial diving operations and demonstrated proficiency during working dives.

2. Field experience is defined as those days spent (offshore, inland lakes, harbors, rivers, etc.) participating as a crew member in diving operations at the level of competency determined by prior training and demonstrated proficiency.

3. Diving proficiency establishes the required minimum number of open-water working dives required to obtain various designations. All dives must be performed during a 24-month period immediately prior to issuance of the designation. Work must be performed during each dive with proper supervision. All dives must have a minimum of 20 minutes bottom time. A number of shorter-duration dives may be combined to equal one dive of the required 20-minute bottom time.

4. **Advancement** to higher designations requires completion of training and experience for all lower designations.

### Minimum Qualifications:

- **Entry-Level Tender/Diver**

  Commercial diver training of at least 625 documented hours of formal instruction in subjects set forth in the ANSI Standard.[2]

- **Advanced Certifications**

  As defined in Matrix in Section 3.

- **Others**

  Technical proficiency as appropriate to the specific diving mode as detailed under the ADCI certification card program requirements or appropriate section for these standards.

## 2.2.1 ENTRY LEVEL ROV PILOT-TECHNICIAN PROGRAM CONTENT REQUIREMENTS

### 2.2.1 RIGGING - 16 HOURS

### 2.2.2 ENVIRONMENTAL CONSIDERATIONS - 4 HOURS

### 2.2.3 FLUID POWER, HYDRAULICS, AND MECHANICAL SYSTEMS - REQUIRED HOURS 40

Basic understanding of the concepts and applications of fluid power technology and the necessary skills for troubleshooting hydraulic systems in the field. General concept of fluid power systems including an introduction to energy input, energy output, energy control, system, and auxiliary components. Design, repair, and maintenance of launch and recovery equipment which may include hoses, sensors and components associated with ROV hydraulics systems.

### 2.2.4 ELECTRICITY AND ELECTRONICS - REQUIRED HOURS 60

Fundamentals of electricity and electronics by developing introductory analysis, construction and troubleshooting techniques for DC and AC circuits. Understanding of power supplies, transistors, amplifiers and digital logic families. Safe electrical practices, including industrial high voltage systems, read and follow schematics, and demonstrate proper wiring and soldering techniques. Electrical measurements shall be performed using test tools including multimeters and oscilloscopes. Additionally, systems, applications, electronics, and safety requirements specific to the marine and ROV environments shall be presented including the understanding of the design, repair, and integration of cabling, tether, communication devices, sensors, and components. Use of test equipment and protocols in troubleshooting methods.

### 2.2.5 BASIC PRINCIPLES AND CLASSIFICATION OF ROV SYSTEMS - 4 HOURS

Provide students with an understanding of basic principles of ROV systems including history, vehicle classification and function, service areas of industry and the major components of a ROV system.

### 2.2.6 ROV COMPONENTS -DETAILED - 40 HOURS

- Cameras and video systems
- Lighting systems
- Buoyancy and floatation
- Manipulator systems
- Cameras and video systems
- Lighting systems
- Buoyancy and floatation
- Manipulator systems
- Positioning systems/tracking systems

- Propulsion systems
- Sonar systems
- Navigation systems
- Tether management and handling systems
- Vehicle control systems
- ROV topside control center
- Auxiliary systems
  - o CP
  - o Laser
  - o Inspection and Scientific sampling
  - o Data logging

### 2.2.7 ROV OPERATIONS -DOCUMENTED AND SIGNED OFF - 40 HOURS

1. Pilot in command - 10 Hours

   This is time under operational activities-i.e. ROV in the water. ROV in-water operation time must include 75% of class II or above ROV as defined in 9.2.1.

2. Navigator - 10 Hours

   This is time under operational activities-i.e. ROV in the water.

3. Deck operations/tether handling - 20 Hours

## 2.3 DIVER MEDICAL REQUIREMENTS

It is recommended that candidates attending formal commercial diver training programs and schools follow the ADCI medical and examination guidelines outlined in this section.

### 2.3.1 GENERAL

For persons engaged as divers, or otherwise subjected to hyperbaric conditions, the following ADCI medical examinations (or equivalent) are required:

1. An initial medical examination by a physician qualified to perform commercial diver medical examination following the ADCI recommended guidelines.
2. Examinations are required on an annual basis.
3. A re-examination after a diving-related injury or illness as needed to determine fitness to return to diving duty. For the purposes of these medical requirements all examinations are to be performed only by licensed physicians qualified to perform commercial diver medical examinations. Must have licensed physician signature to be legible and/or stamped, with their medical designation clearly indicated. Non-physicians are not recognized by the ADCI as being qualified to perform commercial diver medical examinations. For dive team members *not* engaged in diving activity or otherwise subjected to hyperbaric conditions, the ADCI requires yearly documented *physical examination performed by a physician*.

### 2.3.2 PHYSICAL EXAMINATION

1. For persons engaged as divers or otherwise subjected to hyperbaric conditions, the initial exam and periodic medical re-examination will be recorded using the ADC diving medical examination form and will include the following:
   - Work history.
   - The tests required in Section 2, Table 1 as appropriate.
   - Any tests deemed necessary to establish the presence of any of the disqualifying conditions listed in this section.
   - Any additional tests the physician deems necessary.

2. All persons engaged as divers or otherwise subjected to hyperbaric conditions are required to get an annual exam. More frequent or extensive examination(s), including a complete medical re-examination, should be required if there have been any incidents (illness, accidents, etc.) during the course of that year that may have caused a change in the individual's medical condition. The diver is required to notify the diving medical examiner of any changes in his/her medical condition including any change in medications.

### 2.3.3 RE-EXAMINATION AFTER INJURY OR ILLNESS

Any person engaged as a diver, or otherwise exposed to hyperbaric conditions, will have a medical examination following a known diving-related injury or illness that requires hospitalization or known decompression sickness with audio-vestibular, central nervous system dysfunction or arterial gas embolism. Divers experiencing type I decompression sickness that is treated and symptoms completely resolve with a single treatment table do not need to be seen by a diving medical examiner prior to return to diving.

1. Any person engaged as a diver, or otherwise exposed to hyperbaric conditions, will have a medical evaluation following any non-diving injury or illness that requires any prescription medication, any surgical procedure or any hospitalization.
2. The person should not be permitted to return to work as a diver, or otherwise be subjected to hyperbaric conditions, until he or she is released by a physician recognized by the ADCI to do so.
3. The examining physician should determine the scope of the examination in light of the nature of the injury or illness.

### 2.3.4 TABLE 1 - MEDICAL TESTS FOR DIVING

| Test | Initial | Frequency | Comments |
|---|---|---|---|
| **History & Physical** | X | Annual Frequency | Include predisposition to unconsciousness, vomiting, cardiac arrest, impairment of oxygen transport, serious blood loss or anything that, in the opinion of the examining physician, will interfere with effective underwater work. |
| **Chest X-ray** | X | Every 3 Years | PA and lateral (Projection: 14" x 17" minimum) every three years unless medical conditions dictate otherwise. |
| **EKG: Standard (12 Leads)** | X | Annual >35 | Required initially to establish baseline; annually after age 35; and as medically indicated. |
| **Framingham Risk Score** | X | Annual >35 | Required annually after the age of 35, consider before 35. |
| **Stress Echo / Nuclear** | X | | Required as medically indicated or if the Framingham Risk Score indicates risk of >10%. |
| **Spirometry** | X | Annual | Required including FVC, FEV1. Tests should be compared with NHANESIII reference values for determining percent of predicted |
| **Audiogram** | X | Annual | Threshold audiogram by pure tone audiometry; bone conduction audiogram as medically indicated. |
| **Visual Acuity** | X | Annual | Required initially and annually. |
| **Color Blindness** | X | | Required initially. Consider annually. |
| **Complete Blood Count** | X | Annual | |
| **Routine Urinalysis** | X | Annual | |
| **Urine Drug Screen** | Optional | Optional Annual | As medically indicated or otherwise required. |
| **Lipid Panel** | X | Annual >35 | Required annually after the age of 35. |
| **TB screening** | Optional | Optional Annual | Optional. |
| **Comprehensive Metabolic Profile** | Optional | Optional Annual | Optional. |
| **Hemoglobin A1c** | Optional* | Optional Annual* | *Required annually if known history of diabetes, but otherwise optional at the discretion of the physician. |
| **Pregnancy Test** | Optional | Optional | Recommended prior to saturation diving. |
| **EEG** | | | Required only as medically indicated. |

### 2.3.5 PHYSICIAN'S WRITTEN REPORT

A written report outlining a person's medical condition and fitness to engage in commercial diving or other hyperbaric activities should be provided by the examining physician at any time a physical examination is required herein. The written **physical examination form** should be accompanied with a completed copy of the standard **ADCI medical history form**.

The examining physician should be qualified by experience or training to conduct the commercial diver physical examination.

### 2.3.6 ABSOLUTE DISQUALIFYING CONDITIONS

A person having any of the following conditions, as determined by a physician's examination, shall be disqualified from engaging in diving or other hyperbaric activities.

- History of seizures other than early childhood febrile seizure, oxygen toxicity seizure, withdrawal seizure, unintentional medication related seizure.
- Cystic, bullous or cavitary disease of the lungs, significant obstructive or restrictive lung disease and/or spontaneous pneumothorax. Incidentally detected small blebs (extremely common in the general population) may be considered for waiver at the discretion of the

evaluating physician.

- Chronic inability to equalize sinus and middle ear pressure.
- Significant central or peripheral nervous system disease or impairment.
- Chronic alcoholism, drug abuse or dependence or history of psychosis.
- Hemoglobinpathies associated with comorbidities.
- Any person engaged as a diver, or otherwise exposed to hyperbaric conditions, will have a medical evaluation following any non-diving injury or illness that requires any prescription medication, any surgical procedure or any hospitalization.
- Untreated or persistent/metastatic or other significant malignancies under active treatment. Following treatment of cancer, fitness to return to diving should be evaluated by an experienced diving physician as described in section 2.4.1 and in consultation with the treating oncologist.
- Hearing impairment in the better ear should be greater than 40 dB average in the 500, 1000, and 2000 Hz frequencies.
- Untreated or symptomatic juxsta-articular osteonecrosis.
- Chronic conditions requiring continuous control by medication that increases risks in diving.
- Pregnancy.

### 2.3.7 WITHDRAWAL FROM HYPERBARIC CONDITIONS FOR DIVERS

It shall be determined on the basis of the physician's examination whether a person's health will be materially impaired by continued exposure to hyperbaric conditions. The physician should indicate, in the written report, any limitations or restrictions that would apply to the person's work activities.

### 2.3.8 MEDICAL RECORD KEEPING

1. An accurate medical record for each person subject to the medical specifications of this section should be established and maintained. The record should include those physical examinations specified herein, including the **ADCI medical history/physical examination forms** and the physician's written report.
2. The medical record shall be maintained for a minimum of five years from the date of the last hyperbaric exposure unless otherwise prescribed by law.

## 2.4 MEDICAL GUIDELINES AND RECOMMENDATIONS

### 2.4.1 INTRODUCTION

If any further clarification of this recommended standard is desired, please contact the ADCI.

The following recommendations are set forth by the ADCI and are intended to be used with the ADCI medical history/physical examination forms. They deal with specific aspects of the subject's physical fitness to dive by item number. These standards are offered with what we believe, in most cases, to be the minimum requirements. The use of these standards is intended to be tempered with the good judgment of the examining physician. Where there is doubt about the medical fitness of the subject, the examining physician should seek the further opinion and recommendations of an appropriate specialist in that field. Particular attention must be paid to past medical and diving history. In general, a high standard of physical and mental health is required for diving. Consequently, in addition to excluding major disqualifying medical conditions, examining physicians should identify and give careful consideration to minor, chronic, recurring or temporary mental or physical illnesses that may distract the diver and cause him or her to ignore factors concerned with his or her own safety or others' safety.

It is recommended that the medical examination be performed by a physician that has completed formal training or has experience in the medical assessment of fitness for commercial diving. Examinations shall not be performed by non-physicians.

The spectrum of commercial diving includes industrial tasks performed from just below the surface to deep saturation diving. Job descriptions and therefore job-limiting disabilities may vary widely. These standards, in general, apply to all divers. Some consideration must be given to the subject's medical history, work history, age, etc. Within commercial diving it may be that a diver is fit to perform some jobs but not others.

There is no minimum or maximum age limit, providing all the medical standards can be met. The ADCI does not issue commercial diver certification cards to persons younger than 18 years of age. Serious consideration must be given to the need for all divers to have adequate reserves of pulmonary and cardiovascular fitness for use in an emergency. The lack of these reserves may possibly lead to the termination of a professional diving career. The examining physician should exercise the appropriate professional judgment to determine whether in particular circumstances additional testing may be warranted. Disqualification for an inability to meet any of these standards must be determined on a case-by-case basis.

### 2.4.2 ADCI PHYSICAL EXAMINATION STANDARDS

Patient history is recorded on pages 2-15 through 2-16 of the form set. Pages 2-17 and 2-18 are used to record specific findings during the conduct of the examination.

The following headings refer to and explain the numbered boxes on the **ADCI physical examination form** on pages 2-17 and 2-18. A sample copy of these forms is enclosed in this standard. Use of these forms ensures quality and consistency throughout the commercial diving industry. These forms may be obtained from the ADCI website.

| | | |
|---|---|---|
| 1 | **Name** | Record. |
| 2 | **Last 4 digits of Social Security Number or Passport Number** | Record. |
| 3 | **Height** | No set limits. |
| 4 | **Weight** | The weight limits listed in the maximum allowable weight chart (2.4.9) should apply. If a diver exceeds these limits and the cognizant physician feels the increase is due to muscular build and physical fitness, a variance may be appropriate. A variance may be appropriate for divers who do not meet the weight limits but are at 23% body fat or less (males), 34% (females) as measured by impedance or hydrostatic fat testing. Furthermore, individuals who fall within these weight limits but who present an excess of fatty tissue should be disqualified. |
| 5 | **Body Mass Index (BMI)** | BMI < 28 for initial evaluation. For annual evaluation risk factor modification recommended for BMI > 28 and body fat exceeding limits, consider fitness assessment such as functional stress testing. BMI >30 (clinical obesity) is considered disqualifying.<br>Calculation for $BMI = \frac{\text{weight in pounds} \times 703}{\text{height in inches}^2}$<br>*See also U.S. Navy height and weight table. |
| 6 | **Body Fat** | Optional. <23% for males, <34% for females. US Navy standard |
| 7 | **Temperature** | The diver should be free of any infection/disease that would cause an abnormal temperature. |
| 8 | **Blood Pressure** | The resting blood pressure should not exceed 140/90 mm Hg. In cases of apparent hypertension, repeated daily blood pressure determinations should be made before a final decision is made. The blood pressure should be controlled without target organ damage. Beta blockers and diuretics are not acceptable. Medications required to control blood pressure should be noted on the physical exam form. |
| 9 | **Pulse/Rhythm** | Persistent tachycardia, arrhythmia except of the sinus type, or other significant disturbance of the heart or vascular system should be evaluated and may be disqualifying. |
| 10 | **General Appearance/ Hygiene** | Record. |
| 11 | **Distant Vision** | Vision must be tested with and without correction when applicable. Should have vision corrected to 20/40, in both eyes. Monocular vision is not necessarily disqualifying for commercial diving. Divers who have had vision corrective surgery should be restricted from diving until cleared by a qualified diving physician and ophthalmologist. |
| 12 | **Near Vision** | Correctable to 20/40. |
| 13 | **Color Vision** | Record. Color blindness does not disqualify for diving, but diver must have color vision specific for duties. |
| 14 | **Field of Vision** | A minimum of 85 degrees field of vision is required. |
| 15 | **Contact Lenses** | Record if used. Appropriate lenses for diving may be used (soft lenses are the preferred contact lenses for diving / gas permeable fenestrated hard lens may be permitted). Vision must be recorded with and without contact lenses. |
| 16 | **Head, Face and Scalp** | Some causes for rejection may include:<br>a) Deformities of the skull in the nature of depressions, exostosis, etc., of a degree that would prevent the individual from wearing required equipment.<br>b) Deformities of the skull of any degree associated with evidence of disease of the brain, spinal cord or peripheral nerves.<br>c) Loss or congenital absence of the bony substance of the skull. |

| | | |
|---|---|---|
| 17 | **Neck** | Conditions affecting the neck must not impair the diver to cause insufficient range of motion.<br>The causes for rejection may include:<br>a) Cervical ribs if symptomatic.<br>b) Fistula, chronic draining, of any type.<br>c) Spastic contraction of the muscles of the neck of a persistent and chronic nature.<br>d) Known cervical disc disease with neural impingement or radicular symptoms. |
| 18 | **Eyes** | Active pathology or previous eye surgery may be cause for restriction or rejection. Divers who have had vision corrective surgery should be restricted from diving until cleared by a qualified diving physician and ophthalmologist. History of cataract surgery with intraocular lens implant is not disqualifying. |
| 19 | **Fundus** | Optional. No pathology. |
| 20-24 | **Ears & Nose** | The following conditions are disqualifying:<br>a) Acute disease including vestibular disease.<br>b) Chronic serious otitis.<br>c) Active otitis media.<br>d) Current perforation of the tympanic membrane.<br>e) PE tubes in place.<br>f) Any significant nasal or pharyngeal respiratory obstruction.<br>g) Chronic sinusitis if not readily controlled.<br>h) Speech impediments due to organic defects.<br>i) Inability to equalize pressure due to any cause.<br>j) Recurrent or persistent vertigo.<br>k) Recent piercing(s) must be fully healed prior to diving.<br>If Eustachian tube dysfunction is suspected, then referral or testing should be done. Adequately repaired or healed round window ruptures that have no significant residual deficits may be approved for diving. |
| 25 | **Mouth and Throat** | a) Candidate should have a high degree of dental fitness; any abnormalities of dentition or malformation of the mandible likely to impair the diver's ability to securely and easily retain any standard equipment mouthpiece should disqualify.<br>b) Removable dentures should not be worn while diving.<br>c) Severe dental caries is disqualifying until repaired.<br>d) History of tobacco use should be evaluated. |
| 26 | **Chest (include breasts)** | Note any chest deformities, breast abnormalities or masses. |
| 27 | **Lungs** | Pulmonary: Congenital and acquired defects that may restrict pulmonary function, cause air entrapment, or affect the ventilation-perfusion or balance shall be disqualifying for both initial training and continuation. Obstructive or restrictive pulmonary functions requires further evaluation. Pulmonary disease requiring medication use may be disqualifying. History of recurrent or spontaneous pneumothorax is disqualifying. History of smoking or use of e-cigarettes "vaping" should be evaluated. |
| 28 | **Heart (thrust, size, rhythm, sounds)** | Any evidence of heart disease or arrhythmias other than sinus arrhythmias must be fully investigated. For evaluation purposes, Bruce protocol functional stress testing through stage III must be to at least 10 METS without evidence of ischemia. Pacemakers and implantable cardiac defibrillators are disqualifying. PFO repairs are not disqualifying. Routine PFO testing is not recommended. Coumadin or any anticoagulants, antiplatlet medications and aspirin (except low dose aspirin) are considered disqualifying. Ejection fractions must be at least 40% if measured. |
| 29 | **Pulse** | Record. Peripheral pulses should be regular, full and symmetric. Resting pulse rate should be less than 100 BPM. |
| 30 | **Vascular System (varicosities, etc.)** | Cardiovascular system: The cardiovascular system shall be without significant abnormality in all respects as determined by physical examination and tests as may be indicated. Evidence of symptomatic arteriosclerosis, severe varicose veins and marked symptomatic hemorrhoids may be disqualifying. Carotid or abdominal bruits require further evaluation. |

| | | |
|---|---|---|
| 31 | **Abdomen and Viscera** | a) Active peptic ulceration should be disqualifying until treated and healing has been documented. History of gastrointestinal bleeding may be disqualifying from diving and is disqualifying from saturation diving.<br>b) Any other chronic gastrointestinal disease (e.g., Chrone's disease, ulcerative colitis, cholelithiasis) may be disqualifying.<br>c) Hepatitis may be disqualifying.<br>d) Colostomies should be disqualifying for saturation diving. |
| 32 | **Hernia (all types)** | All inguinal or femoral hernias are disqualifying until repaired. Ventral hernias should be assessed for strangulation risk by a surgeon prior to diving. |
| 33 | **Endocrine System** | Diabetes controlled only with diet and exercise and with Hgb A1C < 7.0 is acceptable. History of thyroid disease adequately controlled with medication is acceptable. Other endocrine disorders requiring medication may be disqualifying. |
| 34 | **G-U System (genital-urinary)** | a) Gonococcal disease, syphilis, chlamydia and genital herpes will disqualify until adequately treated.<br>b) Evidence or history of nephrolithiasis must be fully investigated and treated and may be disqualifying. History of kidney stones is disqualifying for saturation diving.<br>c) Any renal insufficiency or chronic renal disease may be disqualifying.<br>d) Evidence or history of urinary dysfunction or retention must be fully investigated and treated. |
| 35 | **Upper Extremities (strength, ROM)** | Any impairment of musculoskeletal function should be carefully assessed against the general requirements that would interfere with the individual's performance as a diver. Amputations may be disqualifying. Orthopedic internal fixation hardware is not disqualifying if the fracture site is healed. |
| 36 | **Lower Extremities, Except Feet** | Any impairment of musculoskeletal function should be carefully assessed against the general requirements that would interfere with the individual's performance as a diver. Amputations may be disqualifying. Orthopedic internal fixation hardware is not disqualifying if the fracture site is healed. |
| 37 | **Feet** | Any impairment of musculoskeletal function should be carefully assessed against the general requirements that would interfere with the individual's performance as a diver. |
| 38 | **Spine** | Any impairment of musculoskeletal function should be carefully assessed against the general requirements that would interfere with the individual's performance as a diver. Known cervical, thoracic or lumbar disc disease with neural impingement or radicular syptoms may be disqualifying. |
| 39 | **Skin and Lymphatic System** | Acute or chronic disease of the skin or lymphatic system may be disqualifying. Tattoos must be fully healed prior to diving. |
| 40 | **Anus and Rectum** | Any conditions that interfere with normal function (e.g., stricture, prolapse, severe hemorrhoids) may be disqualifying. |
| 41 | **Sphincter Tone** | Note and record. |
| | **Neurological Exam (42-49)** | A full examination of the central and peripheral nervous system should show normal function, but localized minor abnormalities, such as patches of anesthesia, are allowable provided generalized nervous system disease can be excluded. History of seizure other than childhood febrile seizure, oxygen toxicity seizure, withdrawal seizure, unintentional medication related seizure. Intracranial surgery, loss of consciousness of more than 30 minutes, and severe head injury involving more than momentary unconsciousness or concussion, may be disqualifying. If the severity of head injury is in doubt, special consultation and studies should be considered. All neurodegenerative conditions are disqualifying. |

| | | |
|---|---|---|
| 42 | **Cranial Nerves** | Examine, evaluate and record. |
| 43 | **Reflexes** | Should be symmetrical and free from pathology. Document any abnormalities. Pathological reflexes should be evaluated. Asymmetrical reflexes should be documented. |
| 44 | **Cerebellar Function** | Test and record. |
| 45 | **Strength and Tone of Muscles** | Examine and record. Note any asymmetry or loss of tone. |
| 46 | **Propioception/ Stereognosis** | Examine and record. |

| | | |
|---|---|---|
| 47 | **Nystagmus** | Examine and record. Congenital nystagmus is not necessarily disqualifying. End point lateral gaze nystagmus is considered normal. |
| 48 | **Sensations and Vibration** | Examine and record. Vibration should be tested using a 128 Hz tuning fork. Two point discrimination should be tested at the thumb (C6), middle finger (C7) and the little finger (C8) and should be discernable at 5 mm. |
| 49 | **Romberg & Sharpened Romberg** | Examine and record. |
| 50 | **Miscellaneous Remarks and Dermatome Diagram** | Record findings and comments. |
| | **Psychiatric** | Any past or present evidence of psychiatric illness may be disqualifying: any psychiatric illness deemed significant by the physician should be evaluated by a specialist. Personality disorders, bipolar disorders, psychosis, instability and anti-social traits shall be disqualifying . Any psychiatric condition requiring medication may be disqualifying, however temporary situational depression may be approved if stable on low-dose antidepressants that do not affect seizure thresholds or have any side effects of CNS depression. Speech impediment related to stress/anxiety or other psychiatric illness may be disqualifying. |
| | **Substance Use** | Particular attention should be paid to any past or present evidence of alcohol or drug abuse, and may be and indication for referral to specialist. Any current alcohol or drug abuse is disqualifying. Anabolic steroids or other illicit substances are disqualifying. Any abnormalities should be noted in the physical examination form. |
| 51 | **Urinalysis** | Includes color pH, specific gravity, glucose, albumin and micro, abnormalities should be evaluated by the physician. |
| 52 | **Hematology** | Any significant anemia, history of hemolytic disease, or significant abnormalities on Complete Blood count (CBC) must be evaluated; sickle cell disease and other significant hemoglobinopathies are disqualifying. |
| 53 | **Spirometry** | All divers must have periodic spirometry to establish Forced Expiratory Volume at one (1) second (FEV1) and; Forced Vital Capacity (FVC), recording best of three measurements using American Thoracic Society standards. FEV1 and FVC should both be >75% using NHANES reference values. If either or both are below 75%, then the diver should be referred for pulmonary evaluation. Further evaluation should be considered in the event of an acute reduction of FEF 25-75. |
| 54 | **X-ray/Imaging** | a) PA and lateral every three years.<br>b) Long bones (at discretion of evaluating physician): Any lesions, especially juxta-articular, should be evaluated and may be disqualifying.<br>c) Lumbar/sacral spine (at discretion of evaluating physician): Abnormalities associated with symptoms should be further evaluated.<br>d) Spine MRI (at discretion of evaluating physician): Neural impingement on MRI may be disqualifying. |
| 55 | **Electrocardiogram** | Resting standard 12 lead ECG is required on initial examinations and annually after the age of 35. Stress echocardiogram (preferred) or stress ECG required as medically indicated or if the Framingham Risk Score indicates risk of > 10%. |
| 56 | **Audiogram Pure Tone** | A hearing loss in either ear > 40 dB in the range of 500, 1000 and 2000 Hz may be an indication for referral to a specialist for further opinion. Monaural hearing is not disqualifying. |
| 57 | **Comprehensive Metabolic Panel** | Optional at the discretion of the examining physician. Significant abnormalities on Complete Metabolic Panel (CMP) must be evaluated. |
| 58 | **Hemoglobin A1C** | Required for any history of diabetes. Diabetes controlled only with diet and exercise and with Hgb A1C < 7.0 is acceptable. |
| 59 | **Lipid Panel** | Required annually after the age of 35. |
| 60 | **Urine Drug Screen** | All medically indicated or otherwise required. |

## 2.4.3 ADCI MEDICAL HISTORY AND EXAMINATION FORMS

**Association of Diving Contractors International**

**MEDICAL HISTORY FORM**

| Employer | | | Job Title | | Date | |
|---|---|---|---|---|---|---|
| 1. Last Name / First Name / Middle Name | 2. Email Address | | | 3. Date of Birth | 4. Gender | 5. Last 4 No. of SSN |
| 6. Address (Number, Street) | 7. City | 8. State | 9. Zip Code | | 10. Area Code – Phone Number ( ) | |
| 11. Emergency Contact Person – Relationship – Address – Telephone Number | | | | | 12. Cell Phone Number ( ) | |

**13. MEDICAL HISTORY: Have you ever had or been treated for (positive answers must be explained below):**

| Yes | No | | Yes | No | | Yes | No | |
|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | Convulsions or Seizures | ☐ | ☐ | Cardiac Angiogram or ECHO | ☐ | ☐ | Shoulder Injury |
| ☐ | ☐ | Epilepsy | ☐ | ☐ | PFO Repair | ☐ | ☐ | Elbow Injury |
| ☐ | ☐ | Concussion or Head Injury | ☐ | ☐ | High Blood Pressure | ☐ | ☐ | Arm/wrist/hand Injury |
| ☐ | ☐ | Disabling Headaches | ☐ | ☐ | Asthma or Wheezing | ☐ | ☐ | Hip/Leg/Ankle Injury |
| ☐ | ☐ | Loss of Balance/Dizziness | ☐ | ☐ | Coughing up Blood | ☐ | ☐ | Knee Injury or "Trick Knee" |
| ☐ | ☐ | Severe Motion Sickness | ☐ | ☐ | Tuberculosis | ☐ | ☐ | Foot Trouble or Injuries |
| ☐ | ☐ | Unconsciousness | ☐ | ☐ | Shortness of Breath | ☐ | ☐ | Dislocations |
| ☐ | ☐ | Fainting Spells | ☐ | ☐ | Chronic Cough | ☐ | ☐ | Swollen Joints |
| ☐ | ☐ | Wear Contacts/Glasses | ☐ | ☐ | Pneumothorax | ☐ | ☐ | Broken Bones or Fractures |
| ☐ | ☐ | Color Vision Defect | ☐ | ☐ | Lung Disease or Surgery | ☐ | ☐ | Varicose Veins |
| ☐ | ☐ | Eye Disease or Injury | ☐ | ☐ | Gallbladder Disease or Stones | ☐ | ☐ | Muscle Disease or Weakness |
| ☐ | ☐ | Eye Surgery | ☐ | ☐ | Stomach Trouble or Ulcers | ☐ | ☐ | Numbness or Paralysis |
| ☐ | ☐ | Hearing Loss | ☐ | ☐ | Stomach Bleeding | ☐ | ☐ | Sleep Disorders |
| ☐ | ☐ | Ear Disease or Injury | ☐ | ☐ | Frequent Indigestion | ☐ | ☐ | Diabetes |
| ☐ | ☐ | Ear Surgery | ☐ | ☐ | Jaundice | ☐ | ☐ | Goiter or Thyroid Disease |
| ☐ | ☐ | Perforated Eardrum | ☐ | ☐ | Liver Disease or Hepatitis | ☐ | ☐ | Blood Disease |
| ☐ | ☐ | Difficulty Clearing | ☐ | ☐ | Rectal Bleeding/Blood in Stools | ☐ | ☐ | Anemia: Sickle Cell or Other |
| ☐ | ☐ | Nose Bleed | ☐ | ☐ | Hemorrhoids (Piles) | ☐ | ☐ | Skin Rash or Disease |
| ☐ | ☐ | Airway Obstruction | ☐ | ☐ | Gas Pains | ☐ | ☐ | Staph Infections |
| ☐ | ☐ | Hay Fever or Allergies | ☐ | ☐ | Crohn's Disease/Ulcerative Colitis | ☐ | ☐ | Tumor or Cancer |
| ☐ | ☐ | Chest Pain | ☐ | ☐ | Rupture or Hernia | ☐ | ☐ | Claustrophobia |
| ☐ | ☐ | Heart Murmur | ☐ | ☐ | Kidney Disease | ☐ | ☐ | Mental Illness/Depression/Anxiety |
| ☐ | ☐ | Rheumatic Fever | ☐ | ☐ | Kidney Stones | ☐ | ☐ | Nervous Breakdown |
| ☐ | ☐ | Heart Attack | ☐ | ☐ | Protein, Sugar or Blood in Urine | ☐ | ☐ | Any Sexually Transmitted Disease |
| ☐ | ☐ | Abnormal Heart Rhythm | ☐ | ☐ | Joint Pain/Arthritis | ☐ | ☐ | Contagious Disease |
| ☐ | ☐ | Heart Disease | ☐ | ☐ | Back Strain or Injury | ☐ | ☐ | Prior Military Service |
| ☐ | ☐ | Covid 19 Infection | ☐ | ☐ | Spine Problems | ☐ | ☐ | Other Illness or Injury or Any Other Medical Condition |
| | | | ☐ | ☐ | Herniated Disc or Sciatica | | | |
| | | **For Females ONLY** | ☐ | ☐ | Painful Menses | | | |
| ☐ | ☐ | Irregular Menses | ☐ | ☐ | Pregnancy | | | Last Menstrual Period ____________________ |

**PLEASE EXPLAIN THE DETAILS OF EACH ITEM CHECKED YES** ________________________________

**14. LIST ALL SURGERIES** YEAR

**15. LIST ALL HOSPITALIZATIONS** YEAR

**16. LIST ALL INJURIES** YEAR

**17. LIST ALL MEDICATIONS, PRESCRIPTION OR OVER THE COUNTER**

**18. ANSWER THE FOLLOWING QUESTIONS:**

| ***Every Item Checked Yes Must Be Fully Explained Below*** | YES | NO | | YES | NO |
|---|---|---|---|---|---|
| Do you have any physical defects or any partial disabilities? | | | Have you ever resigned, been terminated, or changed jobs for medical reasons? | | |
| Have you ever been rejected or rated for insurance, employment, license, or armed forces for health reasons? | | | Have you ever been dismissed from employment because of excess use of drugs or alcohol? | | |
| Have you ever had illnesses, injuries, or lost time accidents from any work that you have done? | | | Do you have any allergies or reactions to food, chemicals, drugs, insect stings, or marine life? | | |
| Have you been advised to have a surgical operation or medical treatment that has not been done? | | | Are you presently under the care of a physician? Give physician's name and address on the next page. | | |

COMMENTS:

**19. My Personal Physician is:**

Name ______
Address ______
City, State ______
Phone Number ______

**20. DIVING HISTORY** **How long have you been commercial diving?** ______

**Surface Air Diving History**

| | |
|---|---|
| Maximum Depth Surface Air | |
| Maximum Depth Surface Mixed Gas | |
| Longest Bottom Time Air | |
| Longest Bottom Time Mixed Gas | |

**Saturation Diving History**

| | Yes | No |
|---|---|---|
| Heliox | ☐ | ☐ |
| Trimix | ☐ | ☐ |
| Nitrox | ☐ | ☐ |

Maximum Depth ______

Maximum Duration (Days) ______

**21. DIVING EXPERIENCE (Number of years experience):**

Name of Diving School

Air ____
Mixed Gases ____
Saturation ____ ______

**22. INDICATE THE NUMBER OF DECOMPRESSION INCIDENTS**
**If None put 0 (Zero)** **List any residuals**

| | Number | Residuals |
|---|---|---|
| Bends, pain only | | |
| Bends, neurological | | |
| Chokes | | |
| Inner ear | | |

**23. IN DIVING HAVE YOU HAD A HISTORY OF: (Provide details of dates and severity)**

| | Yes | No | Details |
|---|---|---|---|
| Gas Embolism | ☐ | ☐ | |
| Oxygen Toxicity | ☐ | ☐ | |
| $CO_2$ Toxicity | ☐ | ☐ | |
| CO Toxicity | ☐ | ☐ | |
| Ear/Sinus Squeeze | ☐ | ☐ | |
| Ear Drum Rupture | ☐ | ☐ | |
| Deafness | ☐ | ☐ | |

| | Yes | No | Details |
|---|---|---|---|
| Lung Squeeze | ☐ | ☐ | |
| Near Drowning | ☐ | ☐ | |
| Asphyxiation | ☐ | ☐ | |
| Vertigo (Dizziness) | ☐ | ☐ | |
| Pneumothorax | ☐ | ☐ | |
| Nitrogen Narcosis | ☐ | ☐ | |
| Loss of Consciousness | ☐ | ☐ | |

**24. Have you been involved in a diving accident (decompression sickness or others) since your last physical examination?** ☐Yes ☐No

**25. Date of last physical examination:** ______

For what company or organization were you last examined? ______

Name of Physician who performed your last exam ______
Address of Physician ______
City, State ______

**26. Have you ever had any of the following? If so, give approximate date:**

| Yes | No | | Give Date |
|---|---|---|---|
| ☐ | ☐ | Chest X-Ray | |
| ☐ | ☐ | Longbone Series | |
| ☐ | ☐ | Back (Spine) X-Ray | |
| ☐ | ☐ | MRI | |

| Yes | No | | Give Date |
|---|---|---|---|
| ☐ | ☐ | Pulmonary Function Studies | |
| ☐ | ☐ | Audiogram | |
| ☐ | ☐ | EKG | |
| ☐ | ☐ | Exercise (Stress) EKG | |

**27. Physician Remarks:** ______

**I CERTIFY THAT I HAVE REVIEWED THE FOREGOING INFORMATION SUPPLIED BY ME AND THAT IT IS TRUE AND COMPLETE TO THE BEST OF MY KNOWLEDGE. I UNDERSTAND THAT LEAVING OUT OR MISREPRESENTING FACTS CALLED FOR ABOVE MAY BE CAUSE FOR REFUSAL OF EMPLOYMENT OR SEPARATION FROM THE COMPANY. I AUTHORIZE ANY OF THE DOCTORS, HOSPITALS, OR CLINICS MENTIONED ABOVE TO FURNISH THE COMPANY MEDICAL EXAMINER WITH A COMPLETE TRANSCRIPT OF MY MEDICAL RECORD FOR PURPOSES OF PROCESSING MY PHYSICAL EXAM.**

**Date** ______ **Signature** ______ **Page 2 of 4**

# Association of Diving Contractors International
## PHYSICAL EXAMINATION FORM

| Employer | Date | Date of Birth | Age |
|---|---|---|---|
| 1. Last Name | First Name | Middle Name | 2. Last 4 No. of SSN or PASSPORT No. |
| 3. Height (inches) | 4. Weight (pounds) | 5. Body Fat (%) (Optional) | 6. BMI (Optional) |

| 7. Temperature | 8. Blood Pressure / | 9. Pulse/Rhythm | 10. General Appearance/Hygiene | 11. Build |
|---|---|---|---|---|

| 12. Distant Vision: | 13. Near Vision: Jaeger / Near Vision Corrected | 14. Color Vision (Test Performed and Results) |
|---|---|---|
| R. 20/ Corr. to 20/ | R. 20/ R. 20/ | |
| L. 20/ Corr. to 20/ | L. 20/ L. 20/ | |

15. Field of Vision (Degrees) R ° L ° 16. Contact Lenses ☐ Yes ☐ No

| NORMAL | ABNORMAL | Check each item in appropriate column (enter NE for Not Evaluated) | REMARKS |
|---|---|---|---|
| | | 17. Head, Face, Scalp | |
| | | 18. Neck | |
| | | 19. Eyes | |
| | | 20. Ears – General (internal and external canal) | |
| | | 21. Eustachian Tube Function | |
| | | 22. Tympanic Membrane | |
| | | 23. Nose (Septal Alignment) | |
| | | 24. Sinuses | |
| | | 25. Mouth and Throat | |
| | | 26. Chest | |
| | | 27. Lungs | |
| | | 28. Heart (Thrust, Size, Rhythm, Sounds) | |
| | | 29. Pulses (Equality, etc.) | |
| | | 30. Vascular System (Varicosities, etc.) | |
| | | 31. Abdomen and Viscera | |
| | | 32. Hernia (All Types) | |
| | | 33. Endocrine System | |
| | | 34. G-U System | |
| | | 35. Upper Extremities (Strength, ROM) | |
| | | 36. Lower Extremities (Except Feet) | |
| | | 37. Feet | |
| | | 38. Spine | |
| | | 39. Skin, Lymphatics | |
| | | 40. Anus and Rectum | |
| | | 41. Sphincter Tone | |

**NEUROLOGICAL EXAMINATION**

**42. CRANIAL NERVES**

| | | NORMAL | ABNORMAL | NE |
|---|---|---|---|---|
| I | Olfactory | | | |
| II | Optic | | | |
| III | Oculomotor | | | |
| IV | Trochlear | | | |
| V | Trigeminal | | | |
| VI | Abducens | | | |

| | | NORMAL | ABNORMAL | NE |
|---|---|---|---|---|
| VII | Facial | | | |
| VIII | Auditory | | | |
| IX | Glossophayrngeal | | | |
| X | Vagus | | | |
| XI | Spinal Accessory | | | |
| XII | Hypoglossal | | | |

**43. REFLEXES**

**DEEP TENDON**

| | Left 0 | 1 | 2 | 3 | 4 | Right 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|
| Triceps | | | | | | | | | | |
| Biceps | | | | | | | | | | |
| Patella | | | | | | | | | | |
| Achilles | | | | | | | | | | |

**PATHOLOGICAL**

| | Left Present | Left Absent | Right Present | Right Absent |
|---|---|---|---|---|
| Babinski | | | | |
| Hoffman | | | | |
| Ankle Clonus | | | | |

**SUPERFICIAL**

| | Present | Absent | NE |
|---|---|---|---|
| Upper Abdomen | | | |
| Lower Abdomen | | | |
| Cremasteric | | | |

**44. CEREBELLAR FUNCTION**

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Ataxia | | | | | |
| Tremor (intention) | | | | | |

| | Normal | Abnormal |
|---|---|---|
| Finger to Nose | | |
| Heel to Shin (Sliding) | | |
| Rapidly Alternating Movements | | |

**45. MUSCLE STRENGTH TONE**

| | Strength 1 | 2 | 3 | 4 | 5 | Tone Normal | Abnormal |
|---|---|---|---|---|---|---|---|
| Right Upper Extremity | | | | | | | |
| Left Upper Extremity | | | | | | | |
| Right Lower Extremity | | | | | | | |
| Left Lower Extremity | | | | | | | |

**46. PROPIOCEPTION**

| | Left Normal | Left Abnormal | Right Normal | Right Abnormal |
|---|---|---|---|---|
| Joint Position Sense | | | | |
| Stereognosis | | | | |
| Vibratory Sensation | | | | |

**47. NYSTAGMUS**

| | Present | Absent |
|---|---|---|
| End Point Lateral Gaze | | |
| Pathological | | |

**48. SENSATION**

| | Normal | Abnormal |
|---|---|---|
| Hot | | |
| Cold | | |

| | Normal | Abnormal |
|---|---|---|
| Sharp | | |
| Soft | | |

| Two Point Discrimination | |
|---|---|
| Normal | |
| Abnormal | |

**49. ROMBERG**

| | |
|---|---|
| Romberg Absent (normal) | |
| Romberg Present (abnormal) | |
| Sharpened Romberg Normal > 20s | |
| Sharpened Romberg Abnormal < 20s | |

**VIBRATION**

| | Left Normal | Left Abnormal | Right Normal | Right Abnormal |
|---|---|---|---|---|
| Joint Position Sense | | | | |
| Stereognosis | | | | |
| Vibratory Sensation | | | | |

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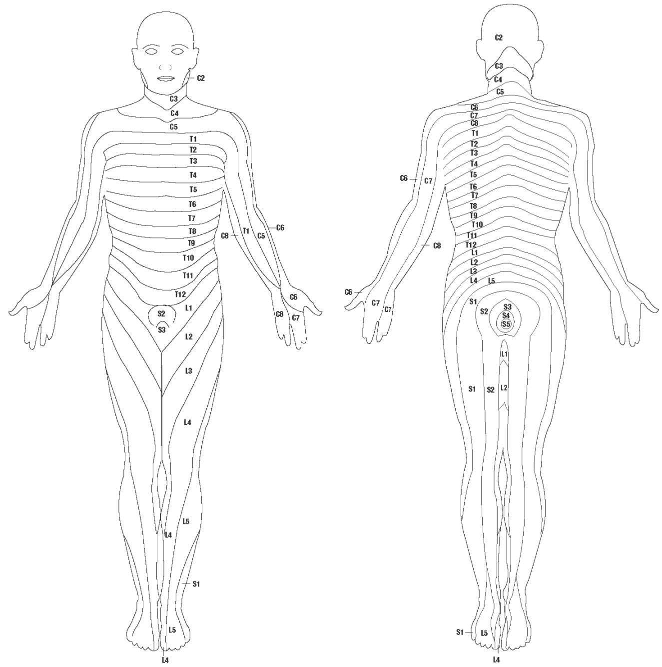
**50. MISCELLANEOUS REMARKS**




**LABORATORY FINDINGS**

**51. Urinalysis**

Color ______
Appearance ______
Sp. Gravity ______
Ph ______
Microscopic: Normal ☐ Abnormal ☐ (See report)

| | 0 | 1+ | 2+ | 3+ | 4+ |
|---|---|---|---|---|---|
| Sugar | | | | | |
| Blood | | | | | |
| Ketones | | | | | |
| Bilirubin | | | | | |
| Protein | | | | | |

**52. Blood Tests**

CBC: Normal ☐ Abnormal ☐

Sickle Cell: ☐ Pos ☐ Neg

Attach Reports

RPR ☐ Pos ☐ Neg

**53. Cardiac Risk Score**

No. of Points ______

10 year risk ______

**54. Pulmonary Function**

FVC ______
FEV1 ______
FEV1/FVC ______

**55. X-ray/MRI**

| | Normal | Abnormal | (Describe) |
|---|---|---|---|
| Chest | ☐ | ☐ | |
| Lumbar Spine | ☐ | ☐ | |
| Long Bones | ☐ | ☐ | |
| MRI | ☐ | ☐ | |

**56. Electrocardiogram**

Static ______
Exercise Stress ______

**57. Audiogram**

| Hz | 500 | 1000 | 2000 | 3000 | 4000 | 6000 | 8000 |
|---|---|---|---|---|---|---|---|
| Left | | | | | | | |
| Right | | | | | | | |

**58. Comprehensive Metabolic Panel** Attach Report

Normal ☐
Abnormal ☐

**Lipid Panel** (if done)

Normal ☐
Abnormal ☐

Comments: ______

**59. Drug Screen**

☐ Not collected
☐ Collected, results sent to employer

**Work Status:**

☐ Fit for diving
☐ Cleared for supervisor
☐ Cleared for topside work only
☐ Cleared with restrictions: ______
☐ Further evaluation needed: ______
☐ Unfit for diving : ______
☐ Unfit

**Comments:** ______

Examinee Name ______

Physician Signature ______

Physician Name ______

Address ______

Phone Number ______

Date of Examination ______

Revision 2016

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### 2.4.4 NEUROPSYCHIATRIC

Any past or present evidence of psychiatric illness may be disqualifying: any psychiatric illness deemed significant by the physician should be evaluated by a specialist. Personality disorders, bipolar disorders, psychosis, instability and anti-social traits shall be disqualifying, however temporary situational depression may be approved if stable on low-dose antidepressants that do not affect seizure thresholds or have any side effects of CNS depression. Speech impediment related to stress/anxiety or other psychiatric illness may be disqualifying.

Particular attention should be paid to any past or present evidence of alcohol or drug abuse, and may be an indication for referral to specialist. Any current alcohol or drug abuse is disqualifying. Anabolic steroids or any other illicit substances are disqualifying. Any abnormalities should be noted in the physical examination form.

### 2.4.5 MEDICATION

The following medications are disqualifying:

1. Amphetamines (including lisdexamfetamine dimesylate) and designer drugs (substituted methylenediosyphenethylamines including MDMA, MMDA, FLEA, EDMA, EFLEA, MDOH, EBDB, MDEA, 5-methyl-MDA and others)
2. Marijuana and synthetic forms of marijuana
3. Phencylidine (PCP)
4. Cocaine
5. Opioids, naturally occurring and synthetics including tramadol and buprenorphine
6. Phosphodiesterase inhibitors such as erectile dysfunction medications within 48 hours of diving
7. Immunosuppressants not recommended in saturation diving
8. Antidepressants which cause CNS depression or may affect seizure threshold (eg. Venlafaxine, bupropion)
9. All antipsychotic medications
10. Muscle relaxants
11. All forms of insulin
12. Oral hypoglycemic medication
13. Anticoagulants or platelet inhibitors (except low-dose aspirin)
14. Benzodiazepines
15. Barbiturates
16. Anxiolytic and/or hypnotic medications
17. Nictotine patches – must be removed while diving
18. Varenicline
19. Beta blockers
20. Diuretics

### 2.4.6 DISCLAIMER

Because of the lack of medical literature concerning commercial diving, these guidelines were developed as a consensus among diving physicians and are intended for only that purpose. The diving medical examiner may use discretion in deviating from these guidelines on an individual basis given the circumstances.

## 2.4.7 BMI TABLES

**BMI Table**

| Height (inches) | BMI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | Body Weight (pounds) | | | | | | | | | |
| 58 | 91 | 96 | 100 | 105 | 110 | 115 | 119 | 124 | 129 | 134 |
| 59 | 94 | 99 | 104 | 109 | 114 | 119 | 124 | 128 | 133 | 138 |
| 60 | 97 | 102 | 107 | 112 | 118 | 123 | 128 | 133 | 138 | 143 |
| 61 | 100 | 106 | 111 | 116 | 122 | 127 | 132 | 137 | 143 | 148 |
| 62 | 104 | 109 | 115 | 120 | 126 | 131 | 136 | 142 | 147 | 153 |
| 63 | 107 | 113 | 118 | 124 | 130 | 135 | 141 | 146 | 152 | 158 |
| 64 | 110 | 116 | 122 | 128 | 134 | 140 | 145 | 151 | 157 | 163 |
| 65 | 114 | 120 | 126 | 132 | 138 | 144 | 150 | 156 | 162 | 168 |
| 66 | 118 | 124 | 130 | 136 | 142 | 148 | 155 | 161 | 167 | 173 |
| 67 | 121 | 127 | 134 | 140 | 146 | 153 | 159 | 166 | 172 | 178 |
| 68 | 125 | 131 | 138 | 144 | 151 | 158 | 164 | 171 | 177 | 184 |
| 69 | 128 | 135 | 142 | 149 | 155 | 162 | 169 | 176 | 182 | 189 |
| 70 | 132 | 139 | 146 | 153 | 160 | 167 | 174 | 181 | 188 | 195 |
| 71 | 136 | 143 | 150 | 157 | 165 | 172 | 179 | 186 | 193 | 200 |
| 72 | 140 | 147 | 154 | 162 | 169 | 177 | 184 | 191 | 199 | 206 |
| 73 | 144 | 151 | 159 | 166 | 174 | 182 | 189 | 197 | 204 | 212 |
| 74 | 148 | 155 | 163 | 171 | 179 | 186 | 194 | 202 | 210 | 218 |
| 75 | 152 | 160 | 168 | 176 | 184 | 192 | 200 | 208 | 216 | 224 |
| 76 | 156 | 164 | 172 | 180 | 189 | 197 | 205 | 213 | 221 | 230 |

**BMI Table**

| Height (Centimeters) | BMI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | Body Weight (kilograms) | | | | | | | | | |
| 147.3 | 41.3 | 43.5 | 45.4 | 47.6 | 49.9 | 52.2 | 54.0 | 56.2 | 58.5 | 60.8 |
| 149.9 | 42.6 | 44.9 | 47.2 | 49.4 | 51.7 | 54.0 | 56.2 | 58.1 | 60.3 | 62.6 |
| 152.4 | 44.0 | 46.3 | 48.5 | 50.8 | 53.5 | 55.8 | 58.1 | 60.3 | 62.6 | 64.9 |
| 154.9 | 45.4 | 48.1 | 50.3 | 52.6 | 55.3 | 57.6 | 59.9 | 62.1 | 64.9 | 67.1 |
| 157.5 | 47.2 | 49.4 | 52.2 | 54.4 | 57.2 | 59.4 | 61.7 | 64.4 | 66.7 | 69.4 |
| 160.0 | 48.5 | 51.3 | 53.5 | 56.2 | 59.0 | 61.2 | 64.0 | 66.2 | 68.9 | 71.7 |
| 162.6 | 49.9 | 52.6 | 55.3 | 58.1 | 60.8 | 63.5 | 65.8 | 68.5 | 71.2 | 73.9 |
| 165.1 | 51.7 | 54.4 | 57.2 | 59.9 | 62.6 | 65.3 | 68.0 | 70.8 | 73.5 | 76.2 |
| 167.6 | 53.5 | 56.2 | 59.0 | 61.7 | 64.4 | 67.1 | 70.3 | 73.0 | 75.7 | 78.5 |
| 170.2 | 54.9 | 57.6 | 60.8 | 63.5 | 66.2 | 69.4 | 72.1 | 75.3 | 78.0 | 80.7 |
| 172.7 | 56.7 | 59.4 | 62.6 | 65.3 | 68.5 | 71.7 | 74.4 | 77.6 | 80.3 | 83.5 |
| 175.3 | 58.1 | 61.2 | 64.4 | 67.6 | 70.3 | 73.5 | 76.7 | 79.8 | 82.6 | 85.7 |
| 177.8 | 59.9 | 63.0 | 66.2 | 69.4 | 72.6 | 75.7 | 78.9 | 82.1 | 85.3 | 88.5 |
| 180.3 | 61.7 | 64.9 | 68.0 | 71.2 | 74.8 | 78.0 | 81.2 | 84.4 | 87.5 | 90.7 |
| 182.9 | 63.5 | 66.7 | 69.9 | 73.5 | 76.7 | 80.3 | 83.5 | 86.6 | 90.3 | 93.4 |
| 185.4 | 65.3 | 68.5 | 72.1 | 75.3 | 78.9 | 82.6 | 85.7 | 89.4 | 92.5 | 96.2 |
| 188.0 | 67.1 | 70.3 | 73.9 | 77.6 | 81.2 | 84.4 | 88.0 | 91.6 | 95.3 | 98.9 |
| 190.5 | 68.9 | 72.6 | 76.2 | 79.8 | 83.5 | 87.1 | 90.7 | 94.3 | 98.0 | 101.6 |
| 193.0 | 70.8 | 74.4 | 78.0 | 81.6 | 85.7 | 89.4 | 93.0 | 96.6 | 100.2 | 104.3 |

## 2.4.8 BODY FAT TABLE AND BODY FAT PERCENTAGES COMPARISON TABLE

| Body Fat Percentages Comparison Table | | |
|---|---|---|
| **Fat Level** | **Men (%)** | **Women (%)** |
| Very Low | 7-10 | 14-17 |
| Low | 10-13 | 17-20 |
| Average | 13-17 | 20-27 |
| High | 17-25 | 27-31 |
| Very High | above 25 | above 31 |

## 2.4.9 MAXIMUM ALLOWABLE WEIGHT CHART

| Maximum Allowable Weight Chart | | |
|---|---|---|
| **Males Weight in Pounds** | **Height (inches)** | **Females Weight in Pounds** |
| 170 | 60 | 170 |
| 176 | 61 | 174 |
| 182 | 62 | 179 |
| 188 | 63 | 182 |
| 194 | 64 | 187 |
| 200 | 65 | 192 |
| 206 | 66 | 196 |
| 212 | 67 | 200 |
| 218 | 68 | 204 |
| 225 | 69 | 209 |
| 230 | 70 | 212 |
| 235 | 71 | 217 |
| 241 | 72 | 222 |
| 247 | 73 | 225 |
| 253 | 74 | 230 |
| 259 | 75 | 234 |
| 265 | 76 | 239 |
| 271 | 77 | 243 |
| 277 | 78 | 248 |
| 283 | 79 | 252 |
| 289 | 80 | 255 |

### 2.4.10 RETURN TO DUTY AFTER DIVING RELATED INCIDENTS

| ADCI Recommendations on Return to Diving | |
|---|---|
| **Diving Related Incident** | **Time to return to diving** |
| Simple pain only with complete resolution after single treatment table | 24 to 72 hours |
| Pain only needing more than one treatment table for complete resolution | 7 days |
| Altered sensation in limbs resolvable by one treatment table | 7 days |
| Motor or other neurological deficit resolvable by one treatment table | 28 days |
| Neurological injury needing several treatment tables to resolve | 4 to 6 months |
| Pulmonary barotrauma resolved | 3 months |
| Pneumothorax resolved (other than spontaneous) | 3 months |
| Vestibular decompression sickness with formal vestibular testing | 4 to 6 months |
| Round window rupture | 6 months after repair |
| Central nervous system oxygen toxicity seizure (after complete evaluation) | 7 days |
| Perforated tympanic membrane | 6 weeks after healed |
| Non-Perforated ENT barotrauma | Determined by examiner |

All cases except simple pain only decompression sickness resolved by a single treatment table must be cleared by medical examination from a qualified diving medical examiner before return to diving.

Persistent neurological deficits following diving related incidents are generally disqualifying.

### 2.4.11 FRAMINGHAM CARDIAC RISK CALCULATOR

The ADC recognizes that cardiac events are second only to drowning as a cause of death while diving. Rather than using an age based criteria for further cardiac screening, the Physicians Diving Advisory Committee is now recommending a risk based approach using the Framingham data. The cardiac risk calculators for men and women are provided below. If the cardiac risk is calculated to be 10% or greater then further testing such as an exercise stress test is recommended.

**Cardiac Risk Calculator - MEN**

| Total Cholesterol | Age 20-39 | Age 40-49 | Age 50-59 | Age 60-69 | Age 70-79 |
|---|---|---|---|---|---|
| <160 | 0 | 0 | 0 | 0 | 0 |
| 160-199 | 4 | 3 | 2 | 1 | 0 |
| 200-239 | 7 | 5 | 3 | 1 | 0 |
| 240-279 | 9 | 6 | 4 | 2 | 1 |
| 280+ | 11 | 8 | 5 | 3 | 1 |

| Age | Points |
|---|---|
| 20-34 | -9 |
| 35-39 | -4 |
| 40-44 | 0 |
| 45-49 | 3 |
| 50-54 | 6 |
| 55-59 | 8 |
| 60-64 | 10 |
| 65-69 | 11 |
| 70-74 | 12 |
| 75-79 | 13 |

| HDL | Points |
|---|---|
| 60+ | -1 |
| 50-59 | 0 |
| 40-49 | 1 |
| <40 | 2 |

| Systolic BP | If Untreated | If Treated |
|---|---|---|
| **<120** | 0 | 0 |
| **120-129** | 0 | 1 |
| **130-139** | 1 | 2 |
| **140-159** | 1 | 2 |
| **160+** | 2 | 3 |

| Age | Smoker | Non-smoker |
|---|---|---|
| **20-39** | 8 | 0 |
| **40-49** | 5 | 0 |
| **50-59** | 3 | 0 |
| **60-69** | 1 | 0 |
| **70-79** | 1 | 0 |

| Enter No of Points | |
|---|---|
| **Age** | |
| **Total Chol** | |
| **HDL Chol** | |
| **Sys B/P** | |
| **Smoking** | |
| **Total** | |

Determine Risk → From Chart

| Point Total | 10-Year Risk |
|---|---|
| <0 | <1% |
| 0 | 1% |
| 1 | 1% |
| 2 | 1% |
| 3 | 1% |
| 4 | 1% |
| 5 | 2% |
| 6 | 2% |
| 7 | 3% |
| 8 | 4% |
| 9 | 5% |
| 10 | 6% |
| 11 | 8% |
| 12 | 10% |
| 13 | 12% |
| 14 | 16% |
| 15 | 20% |
| 16 | 25% |
| 17 or more | ≥30% |

Determine Risk
From Chart

**Cardiac Risk Calculator - WOMEN**

| Total Cholesterol | Age 20-39 | Age 40-49 | Age 50-59 | Age 60-69 | Age 70-79 |
|---|---|---|---|---|---|
| <160 | 0 | 0 | 0 | 0 | 0 |
| 160-199 | 4 | 3 | 2 | 1 | 1 |
| 200-239 | 8 | 6 | 4 | 2 | 1 |
| 240-279 | 11 | 8 | 5 | 3 | 2 |
| 280+ | 13 | 10 | 7 | 4 | 2 |

| Age | Points |
|---|---|
| 20-34 | -7 |
| 35-39 | -3 |
| 40-44 | 0 |
| 45-49 | 3 |
| 50-54 | 6 |
| 55-59 | 8 |
| 60-64 | 10 |
| 65-69 | 12 |
| 70-74 | 14 |
| 75-79 | 16 |

| HDL | Points |
|---|---|
| 60+ | -1 |
| 50-59 | 0 |
| 40-49 | 1 |
| <40 | 2 |

| Systolic BP | If Untreated | If Treated |
|---|---|---|
| <120 | 0 | 0 |
| 120-129 | 1 | 3 |
| 130-139 | 2 | 4 |
| 140-159 | 3 | 5 |
| 160+ | 4 | 6 |

| Age | Smoker | Non-smoker |
|---|---|---|
| 20-39 | 9 | 0 |
| 40-49 | 7 | 0 |
| 50-59 | 4 | 0 |
| 60-69 | 2 | 0 |
| 70-79 | 1 | 0 |

| Enter No of Points | |
|---|---|
| Age | |
| Total Chol | |
| HDL Chol | |
| Sys B/P | |
| Smoking | |
| Total | |

| Point Total | 10-Year Risk |
|---|---|
| <9 | <1% |
| 9 | 1% |
| 10 | 1% |
| 11 | 1% |
| 12 | 1% |
| 13 | 2% |
| 14 | 2% |
| 15 | 3% |
| 16 | 4% |
| 17 | 5% |
| 18 | 6% |
| 19 | 8% |
| 20 | 11% |
| 21 | 14% |
| 22 | 17% |
| 23 | 22% |
| 24 | 27% |
| 25 or more | ≥30% |

Determine Risk
From Chart

## SECTION 3.0

# DIVING PERSONNEL RESPONSIBILITIES, QUALIFICATIONS AND CERTIFICATIONS

**Association of Diving Contractors International, Inc.**

# 3.0 DIVING PERSONNEL RESPONSIBILITIES, QUALIFICATIONS AND CERTIFICATIONS

Titles, duties, responsibilities and capabilities of personnel engaged in commercial diving and underwater operations will vary widely. The employer is responsible for assigning personnel to a diving or underwater operation and will ensure all personnel are qualified by training and/or experience to perform the tasks assigned. The certification designations in this section indicate the minimum duties and responsibilities of dive team members. NOTE: Personel who hold a recognized current DMT certification will not be required to also hold First Aid/CPR/AED/O2 Provider qualifications.

## 3.1 COMMERCIAL DIVER CERTIFICATION PROGRAM

**Certification cards issued by recreational agencies are not recognized as qualifying an individual to perform commercial diving activities in the absence of additional formal commercial diving training from an accredited source.**

### 3.1.1 GENERAL REQUIREMENTS

Member companies of the ADCI employ persons to perform as certified commercial divers in the following categories:

- Entry-level tender/diver.
- Air diver.
- Mixed-gas diver.
- Saturation diver.
- Air-diving supervisor.
- Mixed-gas diving supervisor.
- Saturation-diving supervisor.
- Life-support technician.
- Saturation technician.

These individuals must be properly trained in accordance with the current edition of the **ADCI International Consensus Standards for Commercial Diving and Underwater Operations** and will then continue their path of career progression through on-the-job training and demonstrated field and leadership experience. All ADCI general member company diving personnel need to hold a current ADCI certification card reflective of the assigned tasks to be performed. This certification card needs to be obtained within 90 days of employment with a general member company.[1]

### 3.1.2 QUALIFICATIONS AND CERTIFICATIONS

Diplomas issued by a civilian or military educational organization are for the purpose of attesting that an individual has received the necessary basic formal training to enter a vocational field. Such instruments should not be used to verify that the graduate can perform in the field without further on-the-job training and experience with actual demonstration of competency. All dive crew members must undergo an annual diving physical. The physician can use his/her discretion on those dive crew members who will not be exposed to hyperbaric conditions (i.e, Non-Diving Supervisors).

### 3.1.3 SCOPE AND APPLICABILITY

ADCI has established a program whereby properly trained commercial divers, life-support technicians can obtain a certification card that indicates their qualification and competency level as defined in the **ADCI International Consensus Standards for Commercial Diving and Underwater Operations.**

With the exception of the entry-level tender/diver certification, certification cards issued under this program will be valid for a period of five years from date of issue. Cards can be obtained only by presentation of acceptable documentation that the individual for whom the card is requested has recorded evidence of having completed the requisite training and on-the-job experience necessary to support card issue at the appropriate level of classification.

### 3.1.4 CERTIFICATION AND TRAINING MATRIX
#### International Endorsement Certification Matrix

| CERTIFICATION AND TRAINING MATRIX | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| REQUIREMENT | ENTRY-LEVEL TENDER/ DIVER | AIR DIVER | AIR-DIVING SUPERVISOR | MIXED-GAS DIVER | MIXED-GAS DIVING SUPERVISOR | BELL/SAT DIVER | BELL/SAT DIVING SUPERVISOR | NITROX SUPERVISOR | LIFE-SUPPORT TECHNICIAN |
| **Formal Training** | 625 hours ANSI/ ACDE -01-2015 or recognized equivalent, with required depth and bottom time requirements with commercial or military SCUBA | | | | | | | | |
| **Field Days** | | 100 | 200 | 100 Air 50 Mixed Gas | 350 Air or Mixed Gas | 200 Air or Mixed Gas | 100 days as Mixed Gas and/ or Air Diving Supervisor | | 100 Days as an Assistant LST |
| **Working Dives** | | 30 | 50 | 50 – Air 10 – Mixed Gas | 150 Air or Mixed Gas | 100 Air or Mixed Gas and 10 Bell Runs | | | |
| **Operations on System** | | | | | | 30 Working **Days** | | | |
| **Assistant Supervisor Training Field** | | | 30 Working Days | | 30 Working Days | | 60 Working Days | | |
| **EXAM** | | | EXAM REQUIRED | | EXAM REQUIRED | | EXAM REQUIRED | EXAM REQUIRED | EXAM REQUIRED |

### 3.1.5 DOCUMENTATION ACCEPTED

1. ADCI certification cards may be requested by ADCI member companies by certifying that the person for whom the card is requested fully qualifies to perform duties in the diver classification requested. Member companies are required to have on file, and to retain for a period of five years, copies of information that show evidence that the individual for whom the card is requested does, in fact, possess the necessary training, field experience and required number of working dives.

2. It is recommended that all divers maintain a personal commercial diver log book (ADCI Commercial Diver Log Book or equivalent) to detail hyperbaric exposures.

3. Individual personnel seeking to obtain an ADCI certification card are required to have verifiable evidence necessary to support the application and will, in the case of the diving supervisor level, be required to obtain and provide verifiable endorsements from ADCI (**or other certification authorities recognized by the ADCI**) member companies for whom they shall have records of performance as an assistant diving supervisor or diving supervisor.

4. ADCI Associate Member Commercial Diving Schools:

   Application for the entry-level certification cards may be made by filing with ADCI a listing of the members of each class together with their **assigned identifying numbers**, their dates of birth and a photograph of each member that meets the requirements of this standard. Certification cards will be prepared for each individual identified and returned to the requestor. The cards may be issued ONLY to individuals who actually graduate. Any card furnished to the school for issue to an individual who DOES NOT graduate will be returned to ADCI for disposal and removal of information from the master database.

5. Non-ADCI Member Commercial or Government/Military Diving Schools:

   Application for entry-level certification cards for non-ADCI member commercial or government/military diving schools will be accepted under the following provisions:

   a. That they be formally recognized as an accredited school by a government body.

   b. That the course of instruction offered generally parallels that of the Association of Commercial Diving Educators as recognized in the ADCI International Consensus Standards for Commercial Diving and Underwater Operations to comprise not less than **625** hours of formal instruction in the subjects set forth therein or, as appropriate, the contents of this standard addressed to training and education.

   c. That the course of instruction offered will in all cases parallel that established in the American National Standards Institute document ANSI/ACDE-01-2009; the Secretariat, the Association of Commercial Diving Educators (ACDE); or formal procedures recognized by this association and considered to be at least equal to the procedures necessary for application by a member company of ADCI.

6. The ADCI reserves the right to reject any applications for certification if it cannot be confirmed that the training program/school complies/adheres to the standards outlined in the most current edition of the International Consensus Standards for Commercial Diving and Underwater Operations.

### 3.1.6 CARD ISSUE

The ADCI commercial diver (or other appropriate) certification card will be a 2 1/8-inches x 3 3/8-inches, .030-inch-thick plastic laminated card suitably identified as issued by the ADCI. In the event that a color photo cannot be furnished, a black and white photo will be considered acceptable. With the exception of the entry-level tender/diver certification, all ADCI certification cards, are valid for five years from the date of issuance. The entry-level tender/diver certification card is valid for two years from the date of issuance.

A photograph of the bearer will be laser-scanned onto the card, and the card itself will be protected from being changed or counterfeited by a holographic overlay that is affixed onto the card prior to it being top-coated with a Duraguard™ finish.

### 3.1.7 DATABASE MAINTENANCE

The ADCI will maintain a database of certified card recipients based upon card issue. The database will contain the sequential number for each card, the name, a unique identifier provided by the applicant, as well as the date of issue and the expiration date for all cards issued.

The database information will be maintained confidential. Its existence will be used as a verification tool for replacement of lost cards, renewal of cards, and as a means of generally tracking the numbers of certified commercial divers within industry. The format and content of the database will not be released or changed without ADCI Board of Directors approval.

### 3.1.8 PHOTO INSTRUCTIONS FOR COMMERCIAL DIVER CERTIFICATION CARDS

1. Photo should be taken against a light background color.
2. Photo should be taken of subject with full-face view from a distance of approximately 4 feet from the camera lens.
3. Full-color photograph is preferred.
4. Identify photograph by writing subjects' name below the photo on the bottom margin.
5. Do not apply a paper clip directly to the face of the photograph.

Please remember that the photo will be trimmed to 1.25 inches in height and 1.0 inches wide. Ensure that the submitted photograph is consistent with the ability to have that size photograph laser-scanned onto the certification card.

**FRONT SIDE**

**Association of Diving Contractors International**
Cert. # Cert. Nr.
Expires:
**MIXED-GAS DIVER**
Name: I.D. # I.D. Assigned
Commercial Diver Certification Card

MIXED-GAS DIVER

**Association of Diving Contractors International**
Cert. # Cert. Nr.
Expires:
**BELL/SATURATION DIVER**
Name: I.D. # I.D. Assigned
Commercial Diver Certification Card

BELL/SATURATION DIVER

**Association of Diving Contractors International**
Cert. # Cert. Nr.
Expires:
**SURFACE-SUPPLIED AIR DIVER**
Name: I.D. # I.D. Assigned
Commercial Diver Certification Card

SURFACE-SUPPLIED AIR DIVER

**Association of Diving Contractors International**
Cert. # Cert. Nr.
Expires:
**ENTRY-LEVEL TENDER/DIVER**
Name: I.D. # I.D. Assigned
Commercial Diver Certification Card

ENTRY-LEVEL TENDER/DIVER

**BACK SIDE**

The Association of Diving Contractors International (ADCI) issues this Certification Card to the bearer relying only upon statements or information received that the named individual has completed all training, field experience, and necessary on-the-job performance to warrant identification as a Commercial Diver at the level of experience stated hereon. ADCI accepts no responsibility or liability for the failure of the bearer to perform his or her duties at any stated level of ability.

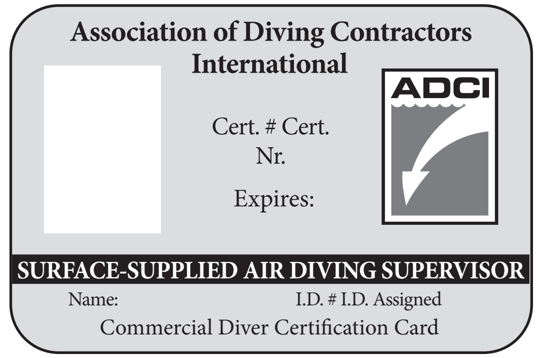
Additional specialized training and/or qualifications gained while engaged in the practice of commercial diving are as recorded in his or her company maintained personnel records and appropriate personal Diver's Log Book.
At a minimum, all commercial diving operations must be undertaken with a minimum of a three man diving team in accordance with the ADCI International Consensus Standards for Commercial Diving Operations (current edition).

The USCG formally recognizes this certification to fully meet the requirements of CFR part 197, subpart B.

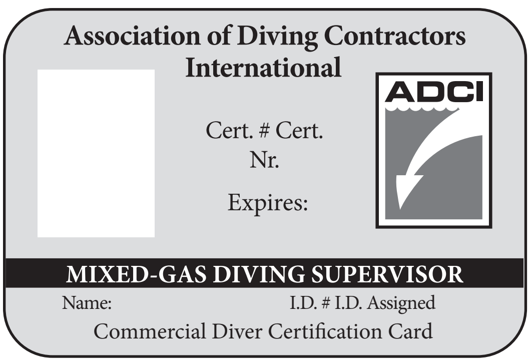
Questions should be directed to ADCI at (281) 893-8388 or Fax (281) 893-5118.

**FRONT SIDE**

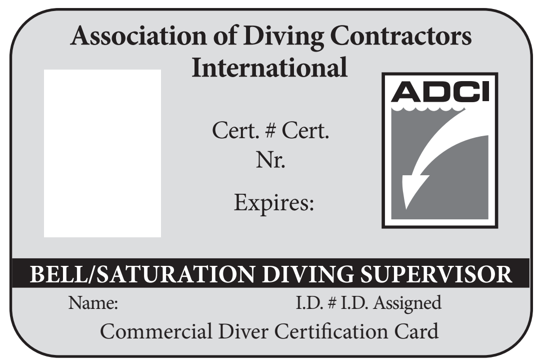

LIFE-SUPPORT TECHNICIAN



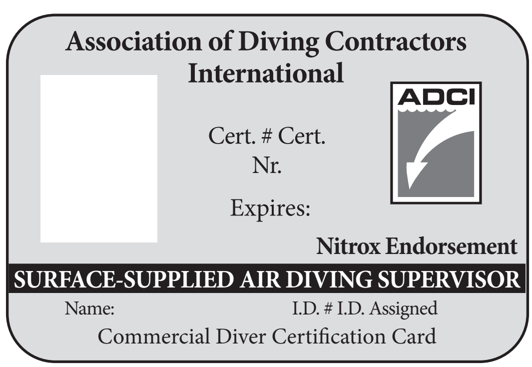

SURFACE-SUPPLIED AIR DIVING SUPERVISOR




MIXED-GAS DIVING SUPERVISOR




BELL/SATURATION DIVING SUPERVISOR




SURFACE-SUPPLIED AIR DIVING SUPERVISOR
NITROX ENDORSEMENT

### 3.1.9 APPLICATIONS

## COMMERCIAL DIVER CERTIFICATION CARD APPLICATION

**The Association of Diving Contractors International**
**5206 FM 1960 West, Suite 202**
**Houston, TX 77069**

**New Application _____**

**Renewal _____**

**APPLICATION FROM ADCI MEMBER COMPANY** (rev. 1/2009)

| Name | Passport Number or Other Numerical Identifier | Photograph Number | CLASSIFICATION<br>Entry-level Tender/Diver (2 years)<br>Air Diver<br>Mixed-gas Diver<br>Bell/Sat Diver | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**NOTE: All applications must be submitted on their respective exam and certification pplications (new combined application).**

In making this application, I understand and acknowledge that the ADCI is relying in full upon my statement that the individual(s) for whom card issue is requested has met the training and experience criteria of the ADCI International Consensus Standards for Commercial Diving and Underwater Operations. By such action, I specifically release the ADCI from any and all liability, which may extend to the issue and use of the requested card(s) to the individual(s) identified above.

I further understand that validity of the requested commercial diver card(s) is as noticed at www.adc-int.org and that prior to expiration, a replacement card must be obtained by submission of a revised application form to note any changes. I verify that all applicants for whom commercial diver certification cards are requested properly maintain a commercial diver log book, and that the log book is available for verification of the level of certification requested.

**Applications for certification can be submitted only for personnel permanently employed by the submitting general member company. Associate member schools applying for graduating students do not fall into this category.**

On behalf of the following persons, I do hereby apply for the issue of ADCI commercial diving certification cards:

_________________________ _________________________

Company | Company Address

_________________________ _________________________

Signature (Company Representative)

_________________________ _________________________

Printed Name (Company Representative)

_________________________ _________________________

Date | Email

# COMMERCIAL DIVER CERTIFICATION CARD APPLICATION

**The Association of Diving Contractors International**
**5206 FM 1960 West, Suite 202**
**Houston, TX 77069**

**New Application _____**

**Renewal _____**

## INDIVIDUAL APPLICATION (Rev. 1/2009)

| | | | |
|---|---|---|---|
| ______________________<br>Name (Please Print)<br><br>______________________<br>Passport Number or<br>Other Numerical Identifier<br><br>______________________<br>Address | | **Classification**<br><br>Entry-Level Tender/Diver (2 years)<br>Air Diver<br>Mixed-gas Diver<br>Bell/Sat Diver | |

**NOTE: All applications must be submitted on their respective exam and certification applications (new combined application).**

In making this application, I understand and acknowledge that the ADCI is relying in full upon my statement that the individual for whom card issue is requested is fully qualified to receive same by having met the training and experience criteria of the ADCI International Consensus Standards for Commercial Diving and Underwater Operations. By such action, I specifically release the ADCI from any and all liability, which may extend to the issue and use of the requested card to the individual identified above.

I further understand that validity of the requested certification card is as noticed at www.adc-int.org and that prior to expiration, a replacement card must be obtained by submission of a revised application form to note any changes.

To support the validity of this request for a commercial diver certification card, I offer the following evidence that I am fully qualified to bear and display such a card:

1. Copies of my diver's log book for the period _____________ 20___ through _________ 20___.
2. A copy of my diploma or certificate of course completion from __________________________.
3. A listing of all commercial diving companies for whom I have worked: (Use separate sheet if necessary).

______________________ ______________________ ______________________________________

______________________ ______________________ ______________________________________

4. If applying for a supervisor card: Satisfactory completion of supervisor certification exam and documentation of qualifications must be submitted.
5. Photo required for new applicants

______________________ ______________________ ______________________________________

Printed Name Phone Email

______________________________________ ______________________________________

Signature Date

## COMMERCIAL DIVER CERTIFICATION CARD APPLICATION

**The Association of Diving Contractors International**
**5206 FM 1960 West, Suite 202**
**Houston, TX 77069**

**New Application _____**

**Renewal _____**

### INDIVIDUAL REPLACEMENT APPLICATION
### (LOST OR STOLEN CARD ONLY) (rev. 1/2009)

| | | | |
|---|---|---|---|
| ______________________<br>Name (Please Print)<br><br>______________________<br>Passport Number or<br>Other Numerical Identifier<br><br>______________________<br>Address | | **Classification**<br>Entry-Level Tender/Diver (2 years)<br>Air Diver<br>Air-Diving Supervisor<br>Mixed-gas Diver<br>Mixed-gas Diving Supervisor<br>Bell/Sat Diver<br>Bell/Sat Diving Supervisor<br>Life-support Technician | |

In making this application, I understand and acknowledge that the ADCI is relying in full upon my statement that the individual for whom card issue is requested is fully qualified to receive same by having met the training and experience criteria of the ADCI International Consensus Standards for Commercial Diving and Underwater Operations. Through this action, I specifically release the ADCI from any and all liability, which may extend to the issue and use of the requested card to the individual identified above.

I further understand that validity of the requested commercial diver certification card is as noticed at www.adc-int.org and at the expiration of same, a new card may be applied for if so desired by presentation of all required documentation.

Printed Name Phone Email

Signature Date

**Include payment of $250.00. This cost includes exam and certification card.**
For countries outside of the U.S., shipping cost will be determined using USPS, FedEx, DHL, UPS.

## SUPERVISOR EXAM AND CERTIFICATION APPLICATION

**(NEW COMBINED APPLICATION) (Rev. 4/2019)**

**The Association of Diving Contractors International**
**5206 FM 1960 West, Suite 202**
**Houston, TX 77069**

### APPLICANT INFORMATION

Full Name: ______________________ ______________________ ______________________
First Middle Last

Address: ______________________________________ ______________________
Apartment/Unit #

______________________ ______________________ ______________________
City State ZIP Code

Province: ______________________ Country: ______________________

Phone: ( ______ ) ______________________ Email Address: ______________________

Passport Number or Other ID Number: ______________________

Supervisor Test and Certification Applied for: ❑ Air Diving ❑ Mixed-Gas ❑ Bell/Sat ❑ Nitrox Endorsement ($250.00)

### COMPANY

**Proctor:** ______________________ **Job Title:** ______________________

**Company:** ______________________ **Phone:** __________ ______________

**Address:** ______________________________________________
**Suite**

______________________ ______________________ ______________________
City State ZIP Code

**Province:** ______________________ **Country:** ______________________

**Email:** ______________________________________________

**If you agree to the terms of the two statements below, please check both boxes.**

❑ **I understand that taking and passing this examination does NOT automatically guarantee issuance of an ADCI supervisor's certification card and that issuance of any requested ADCI supervisor's certification card will be based upon examination performance, as well as the training and experience criteria of the ADCI International Consensus Standards for Commercial Diving Operations, Section 3.0.**

❑ **I certify that the person taking the actual final exam is the candidate whose name appears on this application.**

______________________________________ ______________________
Proctor Signature Date

**Include payment of $250.00. This cost includes exam and certification card.**

For countries outside of the U.S., shipping cost will be determined using USPS, FedEx, DHL, UPS.

# LIFE-SUPPORT TECHNICIAN EXAM AND CERTIFICATION APPLICATION

**(NEW COMBINED APPLICATION) (rev. 1/2009)**

**The Association of Diving Contractors International**
**5206 FM 1960 West, Suite 202**
**Houston, TX 77069**

## APPLICANT INFORMATION

Full Name: ______________________ ______________________ ______________________
Last First M.I.

Address: ______________________________________________ ______________
Street Address Apartment/Unit #

______________________________________ ______________ ______________
City State ZIP Code

Phone: ( _____ ) ______________________ Email Address: ______________________________

Passport Number or Other ID Number: ______________________________________

## COMPANY

Proctor: ______________________ Job Title: ______________________

Company: ______________________ Phone: ( _____ ) ______________________

Address: ______________________________________________

______________________________________________

Email: ______________________________________________

Proctoring Location: ______________________________________________

**If you agree to the terms of the two statements below, please check both boxes**

☐ I understand that taking and passing this examination does NOT automatically guarantee issuance of an ADCI Life-support technician certification card and that issuance of any requested ADCI LST certification card will be based upon examination performance, as well as the training and experience criteria of the ADCI International Consensus Standards for Commercial Diving Operations, Section 2.0

☐ I certify that the person taking the actual final exam is the candidate whose name appears on this application.

______________________________________ ______________________
Signature Date

## 3.2 ENTRY-LEVEL TENDER/DIVER

**All ADCI general member company diving personnel need to hold a current ADCI certification reflective of the assigned tasks to be performed.[1]**

### 3.2.1 RESPONSIBILITIES

The tender/diver is assigned by the diving supervisor or designated diving person in charge (DPIC) to perform various duties, which may include:

- Continuously tend a diver.
- Preparate and support the dive until its completion.
- Support any in-water decompression as required.
- Assist the diver in dressing and undressing.
- Confirm that the diver's equipment is functioning properly and inform the diving supervisor that the diver is ready.
- Tend the diver's umbilical (keeping at least one hand on the umbilical at all times) and be aware of the diver's depth and location at all times. Set up and operate all equipment as directed by the diving supervisor, DPIC or his or her representative.
- Perform routine maintenance on diving equipment.
- Repair such equipment as he or she is qualified to check-out to repair.
- Assist in topside work as required or directed.
- Be alert for and immediately report conditions that may be hazardous or unsafe.
- Maintain certification in first aid and CPR.
- Properly operate a decompression chamber as required for decompression or treatment as directed.
- Maintain communication with the chamber occupants.
- Properly complete all paperwork as required by employer policy and/or governmental regulations.
- Do not perform any other task while operating the chamber.
- Perform tasks as a diver or standby diver when directed by the supervisor. A tender/diver who dives shall be subject to the duties and responsibilities of a diver within the limitations of his or her assignment.
- When required, ride the chamber with the diver during decompression or treatment. This inside tender/diver must be familiar with and alert for the symptoms of oxygen toxicity.
- Report to the diving supervisor any recent medical treatment or illness so that a proper determination can be made concerning fitness and/or ability to dive.
- Immediately report all symptoms or suspected symptoms of DCS to the diving supervisor as early and accurately as possible.
- Report to the diving supervisor any defect or malfunction of the diving equipment provided for the diving operation.
- Read, understand and comply with all employer's policies and applicable governmental regulations, as they relate to their qualifications or performance while engaging in diving operations.

**In the event a tender/diver is assigned a task for which he or she does not feel qualified either by training and/or experience, he or she shall immediately inform the diving supervisor, DPIC or his or her representative.**

### 3.2.2 QUALIFICATIONS AND CERTIFICATIONS

- ADCI Entry-level/tender diver certification card.
- Before being exposed to hyperbaric conditions, the tender/diver must be medically certified as "fit to dive."
- Valid CPR and first aid certification.
- High school graduate or equivalent and no less than 18 years old.

### 3.2.3 CERTIFICATION CARD DESCRIPTION

All graduates of ADCI member schools who complete a commercial diver training-program consisting of a minimum of 625[2] hours of formal instruction in accordance with the provisions of the ADCI International Consensus Standards for Commercial Diving and Underwater Operations, including reference to the American National Standard for Divers (ANSI) Secretariat of the Association of Commercial Diving Educators (ACDE), are eligible.

This card will be issued to all graduates of recognized commercial diver training-programs consisting of 625[2] hours. Non-members of ADCI may apply to receive this type of certification card by presenting evidence that they have attended a recognized course of formal instruction consistent with the provisions of the ADCI International Consensus Standards for Commercial Diving and Underwater Operations.

### 3.2.4 CERTIFICATION CARD REQUIREMENTS

(Requirements located in Section 3.1.4: **Certification and Training Matrix.**)

## 3.3 SURFACE-SUPPLIED AIR DIVER

**All ADCI general member company diving personnel need to hold a current ADCI certification reflective of the assigned tasks to be performed.[1]**

### 3.3.1 RESPONSIBILITIES

The diver is assigned by the supervisor to perform specific tasks in the water and topside.

A diver must be medically certified as fit to dive, have completed a formal commercial diving course of instruction, have detailed knowledge of diving theory and practice, and have a full understanding of the diving equipment in use and of the tasks assigned. All divers shall be in possession of an up-to-date diver's log book, which can be used to establish levels of experience.

Each diver, while carrying out his or her duties and responsibilities, shall:

- Accomplish all tasks assigned by the diving supervisor. In the event the diver is assigned a task for which he or she does not feel competent either by training and/or experience, the diver shall immediately inform the diving supervisor.
- Have adequate knowledge, training and familiarization with all life-support and ancillary equipment designated to the diving operations.
- Read, understand and comply with all employer's policies and applicable governmental regulations, as they relate to their qualifications or performance while engaging in diving operations.
- Have reviewed and be familiar with the Job Hazard Analysis (JHA).
- Maintain a high level of physical fitness.
- Comply with all commands or instructions from the diving supervisor or designated diving person in charge (DPIC) during the conduct of diving operations.
- Ensure that the deepest depth attained during his or her dive has been established before ascent.
- Safely transition from the water to the decompression chamber without avoidable delay.
- Act as a standby diver when directed to do so. Be capable and qualified to carry out all of the duties and responsibilities of the diver as set forth above. (The standby diver is the individual possessing the required training and experience to enter the water at the diving station in order to render assistance to a stricken diver). While acting as a standby diver, the diver shall:
    a) Have attached his or her diving helmet or mask to the standby diver's umbilical in a wrench-tight status and then check for proper flow of breathing medium and for adequate communications. The diving helmet or mask shall be ready to be donned by the standby diver when directed by the diving supervisor. The standby diver shall remain in the immediate vicinity of the diver water entry location and be ready to enter the water when directed by the diving supervisor.
    b) Remain at the station throughout the entire dive, to include all in-water decompression.
    c) Constantly remain abreast of events of the dive.
    d) Not be assigned any tasks that might interfere with duties as a standby diver while there is a diver in the water.
- Act as a chamber operator as required by the diving supervisor.
- Comply with regulations or instructions concerning the use, maintenance, repair and testing of all diving equipment provided for the operation.

- Report to the diving supervisor any recent medical treatment or illness so that a proper determination can be made concerning fitness and/or ability to dive.
- Immediately report all symptoms or suspected symptoms of DCS to the diving supervisor as early and accurately as possible.
- Report to the diving supervisor any defect or malfunction of the diving equipment provided for the diving operation.
- Follow safe diving practices at all times during the diving operation whether on deck or in the water. Bring to the attention of the diving supervisor any questionable items. Be alert for the safety of others as well as himself/herself.
- Assist in the training of new personnel or tender/divers.
- Remain awake and in the vicinity of the decompression chamber for at least one hour following treatment or a hyperbaric exposure outside the no-decompression limits.
- Know and observe the rules for flying after diving or traveling to altitudes higher than the dive site.
- Ensure that diving equipment has been correctly maintained, prepared and tested before each dive. This requirement should never be delegated to others.
- Ensure that medical certificates are up-to-date and recorded in the diver's log book.

### 3.3.2 QUALIFICATIONS AND CERTIFICATION

- ADCI diver certification card for the level of proficiency.
- Before being exposed to hyperbaric conditions, the diver must be medically certified as "fit to dive."
- Valid CPR and first aid certification.

### 3.3.3 CERTIFICATION CARD DESCRIPTION

**This type of card will be issued byADCI to applicants who have:**

Completed a formal course of instruction at a recognized commercial diving school, military training or equivalent consisting of at least 625[2] hours of instruction.

a) Completed at least 100 field days participating in commercial diving operations.
b) Completed at least 30 working dives.

### 3.3.4 CERTIFICATION CARD REQUIREMENTS

(Requirements located in Section 3.1.4: **Certification and Training Matrix.**)

## 3.4 SURFACE-SUPPLIED AIR DIVING SUPERVISOR

**All ADCI general member company diving personnel need to hold a current ADCI certification reflective of the assigned tasks to be performed.[1] All ADCI certified supervisors must take the NITROX ENDORSEMENT exam to supervise NITROX diving operations.**

### 3.4.1 RESPONSIBILITIES

A qualified person shall be identified in writing as the diving supervisor for each diving operation. The diving supervisor is in charge of the planning and execution of the diving operation, including the responsibility for the safety and health of the dive team.

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

In carrying out these responsibilities, the diving supervisor's duties shall include, but not necessarily be limited to, the following:

- Be fully cognizant of all relevant governmental regulatory agency regulations that apply to the diving operation and the diving mode employed, and the employer's basic safe practices/operations manual. See that all rules and regulations are followed.
- Have adequate knowledge, training and familiarization with all life-support and ancillary equipment designated to the diving operations.
- While actually on duty, be in immediate control and available to implement emergency procedures. The diving supervisor is not permitted to dive unless another qualified diver is present who has also been appointed and designated to assume responsibility.

- The diving supervisor must also ensure, prior to commencing a diving operation, in addition to parties directly involved in the diving operation, that masters of craft, pilots of submersibles, harbor masters, managers of offshore installations, pipelines, civil engineering sites, inland waterways, and all persons responsible for anything that affects the diving operation are advised that diving or underwater operations are to be undertaken.
- Ensure diving operations are carried out from a suitable and safe location on the surface.
- Develop or modify and produce pre- and post-dive checklists for the operation.
- Develop and implement emergency/contingency procedures.
- Be aware of the procedures to follow to obtain medical support in the event of an accident, either diving or non-diving related. Ensure a two-way communication system is available at the dive location to obtain emergency assistance.
- Facilitate a Job Hazard Analysis for each task undertaken.
- Establish a dive plan ensuring that sufficient breathing mixtures, supplies and proper equipment are available for safe and timely completion of the job task.
- Assign the duties of all members of the dive team and personally direct them throughout the diving operation.
- Personally inquire if all personnel on the dive team are qualified and physically able to perform tasks assigned. Make an assessment of the physical condition of the divers prior to each dive to determine if any physical impairment is present that would be detrimental to the diver's health and safety in the water or under hyperbaric conditions.
- Ensure that the diving equipment designated for use is:
  - Suitable for the planned diving operation.
  - Compliant with regulatory requirements for the diving mode used.
  - Inspected prior to each dive and is in good working order.
- Ensure that all relevant operating instructions, manuals, decompression tables, treatment schedules and regulatory publications are available at the dive location and are maintained to reflect current changes and/or developments.
- Ensure the detailed briefing of his or her diving team and support personnel, including:
  - Tasks to be undertaken.
  - Unusual hazards or environmental conditions.
- Maintain a depth, bottom time and breathing mix profile at the dive location for each diver during the dive.
- Ensure that each diver is continuously tended while in the water.
- Ensure the dive is terminated when:
  - The diver requests termination.
  - The diver fails to respond to communication or communication is lost between the diver and dive team members at the dive location.
  - Communication is lost between the vessel operator and the diving supervisor during liveboating operations.
  - The diver begins to use his or her diver-carried reserve breathing gas supply.
  - Weather or site conditions are degrading to the extent that diver safety may be compromised.
- Ensure after every dive:
  - The physical condition and wellbeing of the diver is checked by visual observation and verbal questioning.
  - The diver is instructed to report any physical problems or symptoms of decompression sickness or arterial gas embolism.
  - The diver is advised of the location of the nearest operating decompression chamber and is acquainted with the dangers of flying after diving or traveling to altitudes higher than the dive site.
- Ensure after any treatment or dive outside the no-decompression limits:
  - The diver is instructed to remain awake and in the vicinity of a decompression chamber for at least one hour.
  - A trained dive team member is available to operate the decompression chamber.
- Report all accidents or incidents involving personnel as required by employer's rules and relevant governmental regulations.
- Maintain and submit reports required by employer and relevant governmental regulations concerning diving operations and equipment maintenance (testing or repair).
- View and ensure accuracy of diver's personal log book and affix signature to properly record activities.

### 3.4.2 QUALIFICATIONS AND CERTIFICATIONS

- All Dive Supervisors must be vetted by their employer and formally assigned in writing as a Dive Supervisor.
- Successful completion of the ADCI supervisor exam.
- ADCI supervisor certification card for the diving mode.
- Before being exposed to hyperbaric conditions, the supervisor must be medically certified as "fit to dive."
- Valid CPR and first aid certification.

### 3.4.3 CERTIFICATION CARD DESCRIPTION

**This type of card will be issued by ADCI to certified air divers who have:**

a) Successfully completed the ADCI air-diving supervisor's certification examination.

b) Completed an additional 100 field days participating in commercial diving operations during which they shall have performed at least 50 working dives and performed a minimum of 30 days as an assistant surface-supplied air-diving supervisor.

### 3.4.4. CERTIFICATION CARD REQUIREMENTS

(Requirements located in Section 3.1.4: **Certification and Training Matrix.**)

## 3.5 $HeO_2$/MIXED-GAS DIVER

**All ADCI general member company diving personnel need to hold a current ADCI certification reflective of the assigned tasks to be performed.[1]**

### 3.5.1 RESPONSIBILITIES

The diver is assigned by the supervisor to perform specific tasks in the water and topside.

A diver must be medically certified as "fit to dive," have completed a formal commercial diving course of instruction, have detailed knowledge of diving theory and practice, and have a full understanding of the diving equipment in use and of the tasks assigned. All divers shall be in possession of an up-to-date diver's log book, which can be used to establish levels of experience.

Each diver, while carrying out his or her duties and responsibilities, shall:

- Accomplish all tasks assigned by the diving supervisor. In the event the diver is assigned a task for which he or she does not feel competent either by training and/or experience, the diver shall immediately inform the diving supervisor.
- Have adequate knowledge, training and familiarization with all life-support and ancillary equipment designated to the diving operations.
- Read, understand and comply with all employer's policies and applicable governmental regulations, as they relate to qualifications or performance while engaging in diving operations.
- Maintain a high level of physical fitness.
- Comply with all commands or instructions from the diving supervisor or designated diving person in charge (DPIC) during the conduct of diving operations.
- Ensure that the deepest depth attained during the dive has been established before the ascent.
- Safely transition from the water to the decompression chamber without avoidable delay.
- Act as a standby diver when directed to do so. Be capable and qualified to carry out all of the duties and responsibilities of the diver as set forth above. (The standby diver is the individual possessing the required training and experience to enter the water at the diving station in order to render assistance to a stricken diver). While acting as a standby diver, the diver shall:
    a. Have attached his or her diving helmet or mask to the standby diver's umbilical in a wrench-tight status and then check for proper flow of breathing medium and for adequate communications. The diving helmet or mask shall be ready to be donned by the standby diver when directed by the diving supervisor. The standby diver shall remain in the immediate vicinity of the diver water entry location and be ready to enter the water when directed by the diving supervisor.
    b. Remain at the station throughout the entire dive, to include all in-water decompression.
    c. Constantly remain abreast of events of the dive.
    d. Not be assigned any tasks that might interfere with the duties of a standby Ddver while there is a diver in the water.
- Act as a chamber operator as required by the diving supervisor.

- Comply with regulations or instructions concerning the use, maintenance, repair and testing of all diving equipment provided for the operation.
- Report to the diving supervisor any recent medical treatment or illness so that a proper determination can be made concerning fitness and/or ability to dive.
- Immediately report all symptoms or suspected symptoms of DCS to the diving supervisor as early and accurately as possible.
- Report to the diving supervisor any defect or malfunction of the diving equipment provided for the diving operation.
- Follow safe diving practices at all times during the diving operation whether on deck or in the water. Bring to the attention of the diving supervisor any questionable items. Be alert for the safety of others as well as himself or herself.
- Assist in the training of new personnel or tender/divers.
- Remain awake and in the vicinity of the decompression chamber for at least one hour following treatment or a hyperbaric exposure outside the no-decompression limits.
- Know and observe the rules for flying after diving or traveling to altitudes higher than the dive site.
- Ensure that the diving equipment has been correctly maintained, prepared and tested before each dive. This requirement should never be delegated to others.

### 3.5.2 QUALIFICATIONS AND CERTIFICATIONS

- ADCI diver certification card for the level of proficiency.
- Before being exposed to hyperbaric conditions, the diver must be medically certified as "fit to dive."
- Valid CPR and first aid certification.

### 3.5.3 CERTIFICATION CARD DESCRIPTION

**This type of card will be issued by ADCI to certified $HeO_2$/MIXED-GAS divers who have:**

a. Completed at least 100 field days as an air diver.
b. Completed at least 50 working dives as an air diver.
c. Completed at least 50 field days participating in surface mixed-gas diving operations during which they shall have:
   - Performed at least 10 working mixed-gas dives.

### 3.5.4. CERTIFICATION CARD REQUIREMENTS

(Requirements located in Section 3.1.4: **Certification and Training Matrix.**)

## 3.6 $HeO_2$/MIXED-GAS DIVING SUPERVISOR

**All ADCI general member company diving personnel need to hold a current ADCI certification reflective of the assigned tasks to be performed.[1]**

### 3.6.1 RESPONSIBILITIES

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

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

In carrying out these responsibilities, the duties shall include, but not necessarily be limited to, the following:

- Be fully cognizant of all relevant governmental regulatory agency regulations that apply to the diving operation and the diving mode employed and the employer's basic safe practices/operations manual. See that all rules and regulations are followed.
- Have adequate knowledge, training and familiarization with all life-support and ancillary equipment designated to the diving operations.

- While actually on duty, be in immediate control and available to implement emergency procedures. The diving supervisor is not permitted to dive unless another qualified diver is present who has also been appointed and designated to assume responsibility.
- The diving supervisor must also ensure, prior to commencing a diving operation, in addition to parties directly involved in the diving operation, that masters of craft, pilots of submersibles, harbor masters, managers of offshore installations, pipelines, civil engineering sites, inland waterways, and all persons responsible for anything that affects the diving operation are advised that diving or underwater operations are to be undertaken.
- Ensure diving operations are carried out from a suitable and safe location on the surface.
- Develop or modify and produce pre- and post-dive checklists for the operation.
- Develop and implement emergency/contingency procedures.
- Be aware of the procedures to follow to obtain medical support in the event of an accident, either diving or non-diving related. Ensure a two-way communication system is available at the dive location to obtain emergency assistance.
- Perform a job safety analysis for each task undertaken.
- Establish a dive plan ensuring that sufficient breathing mixtures, supplies and proper equipment are available for safe and timely completion of the job task.
- <u>Assign</u> the duties of all members of the dive team and personally direct them throughout the diving operation.
- Personally <u>verify</u> that all personnel on the dive team are qualified and physically able to perform tasks assigned. He or she must make an assessment of the physical condition of the divers prior to each dive to determine if any physical impairment is present that would be detrimental to the divers' health and safety in the water or under hyperbaric conditions.
- <u>Ensure that the diving equipment designated for use is:</u>
  - Suitable for the planned diving operation.
  - Compliant with regulatory requirements for the diving mode used.
  - Inspected prior to each dive and is in good working order.
- Ensure that all relevant operating instructions, manuals, decompression tables, treatment schedules and regulatory publications are available at the dive location and are maintained to reflect current changes and/or developments.
- <u>Ensure the detailed briefing of his or her diving team and support personnel, including:</u>
  - Tasks to be undertaken.
  - Unusual hazards or environmental conditions.
- Make modifications to standard procedures or safety procedures necessitated by the specific diving operation.
- Maintain a depth, bottom time and breathing mix profile at the dive location for each diver during the dive.
- Ensure that each diver is continuously tended while in the water.
- <u>Ensure the dive is terminated when:</u>
  - The diver requests termination.
  - The diver fails to respond to communication or communication is lost between the diver and dive team members at the dive location.
  - Communication is lost between the vessel operator and the diving supervisor during liveboating operations.
  - The diver begins to use his or her diver-carried reserve breathing gas supply.
  - Weather or site conditions are degrading to the extent that diver safety may be compromised.
- <u>Ensure after every dive:</u>
  - The physical condition and wellbeing of the diver is checked by visual observation and verbal questioning.
  - The diver is instructed to report any physical problems or symptoms of decompression sickness or arterial gas embolism.
  - The diver is advised of the location of the nearest operating decompression chamber and is acquainted with the dangers of flying after diving or traveling to altitudes higher than the dive site.
- <u>Ensure after any treatment or dive outside the no-decompression limits</u>:
  - The diver is instructed to remain awake and in the vicinity of a decompression chamber for at least one hour.
  - A trained dive team member is available to operate the decompression chamber.
- Report all accidents or incidents involving personnel as required by employer's rules and relevant governmental regulations.
- Maintain and submit reports required by employer and relevant governmental regulations concerning diving operations and equipment maintenance, testing or repair.

- View and ensure accuracy of diver's personal log book and affix signature to properly record activities.

### 3.6.2 QUALIFICATIONS AND CERTIFICATIONS

- All Dive Supervisors must be vetted by their employer and formally assigned in writing as a Dive Supervisor.
- Successful completion of the ADCI supervisor exam.
- ADCI supervisor certification card for the diving mode.
- Before being exposed to hyperbaric conditions, the supervisor must be medically certified as "fit to dive."
- Valid CPR and first aid certification.

### 3.6.3 CERTIFICATION CARD DESCRIPTION

**This type of card will be issued by ADCI to certified mixed-gas divers who have:**

a. Successfully passed the ADCI $HeO_2$/mixed-gas diving supervisor's certification examination.
b. Completed at least 350 field days as an air or mixed-gas diver.
c. Completed at least 150 working dives as an air or mixed-gas diver.
d. Completed at least 30 working days as an assistant mixed-gas diving supervisor.
e. Individual is also qualified to work as an air diving supervisor.

### 3.6.4. CERTIFICATION CARD REQUIREMENTS

(Requirements located in Section 3.1.4: **Certification and Training Matrix.**)

## 3.7 BELL/SATURATION DIVER

**All ADCI general member company diving personnel need to hold a current ADCI certification reflective of the assigned tasks to be performed.[1]**

### 3.7.1 RESPONSIBILITIES

The diver is assigned by the supervisor to perform specific tasks in the water and topside.

A diver must be medically certified as fit to dive, have completed a formal commercial diving course of instruction, have detailed knowledge of diving theory and practice, and have a full understanding of the diving equipment in use and of the tasks assigned. All divers shall be in possession of an up-to-date diver's log book, which can be used to establish levels of experience.

Each diver, while carrying out his or her duties and responsibilities, shall:

- Accomplish all tasks assigned by the diving supervisor. In the event the diver is assigned a task for which he or she does not feel competent, either by training and/or experience, the diver shall immediately inform the diving supervisor.
- Have adequate knowledge, training and familiarization with all life-support and ancillary equipment designated to the diving operations.
- Read, understand and comply with all employer's policies and with applicable governmental regulations as they relate to qualifications or performance while engaging in diving operations.
- Maintain a high level of physical fitness.
- Comply with all commands or instructions from the diving supervisor or designated diving person in charge (DPIC) during the conduct of diving operations.
- Act as a standby diver when directed to do so. Be capable and qualified to carry out all of the duties and responsibilities of the diver as set forth above. (The standby diver is the individual possessing the required training and experience to enter the water at the diving station in order to render assistance to a stricken diver). While acting as a standby diver, the diver shall:
  a. Have attached his or her diving helmet or mask to the standby diver's umbilical in a wrench-tight status and then check for proper flow of breathing medium and for adequate communications. The diving helmet or mask shall be ready to be donned by the standby diver when directed by the diving supervisor. The standby diver shall remain in the immediate vicinity of the diver water entry location and be ready to enter the water when directed by the diving supervisor.
  b. Monitor bell manifold and applicable analyzers.

Constantly remain abreast of events of the dive.

- Comply with regulations or instructions concerning the use, maintenance, repair and testing of all diving equipment provided for the operation.
- Report to the diving supervisor any recent medical treatment or illness so that a proper determination can be made concerning fitness and/or ability to dive.
- Immediately report all symptoms or suspected symptoms of DCS to the diving supervisor as early and accurately as possible.
- Report to the diving supervisor any defect or malfunction of the diving equipment provided for the diving operation.
- Follow safe diving practices at all times during the diving operation whether on deck or in the water. Bring to the attention of the diving supervisor any questionable items. Be alert for the safety of others as well as himself or herself.
- Assist in the training of new personnel or tender/divers.
- Know and observe the rules for flying after diving or traveling to altitudes higher than the dive site.

### 3.7.2 QUALIFICATIONS AND CERTIFICATIONS

- ADCI diver certification card for the level of proficiency.
- Before being exposed to hyperbaric conditions, the diver must be medically certified as "fit to dive."
- Valid CPR and first aid certification.

### 3.7.3 CERTIFICATION CARD DESCRIPTION

**This type of card will be issued by ADCI to certified divers who have:**

a. Completed at least 200 field days as an air or mixed-gas diver.
b. Completed at least 100 working dives as an air or mixed-gas diver.
c. Performed for at least 30 working days in support of bell/saturation diving operations.
d. Performed at least 10 bell runs.

### 3.7.4. CERTIFICATION CARD REQUIREMENTS

(Requirements located in Section 3.1.4: **Certification and Training Matrix.**)

## 3.8 BELL/SATURATION DIVING SUPERVISOR

**All ADCI general member company diving personnel need to hold a current ADCI certification reflective of the assigned tasks to be performed.[1]**

### 3.8.1 RESPONSIBILITIES

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

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

In carrying out these responsibilities, the diving supervisor's duties shall include, but not necessarily be limited to, the following:

- Be fully cognizant of all relevant governmental regulatory agency regulations that apply to the diving operation and the diving mode employed and the employer's basic safe practices/pperations manual. See that all rules and regulations are followed.
- Have adequate knowledge, training and familiarization with all life-support and ancillary equipment designated to the diving operations.
- While actually on duty, be in immediate control and available to implement emergency procedures.
- Ensure diving operations are carried out from a suitable and safe location on the surface.
- Develop or modify and produce pre- and post-dive checklists for the operation.
- Develop and implement emergency/contingency procedures.
- Be aware of the procedures to follow to obtain medical support in the event of an accident, either diving or non-diving related. Ensure a two-way communication system is available at the dive location to obtain emergency assistance.
- Perform a Job Safety Analysis for each task undertaken.

- Establish a dive plan ensuring that sufficient breathing mixtures, supplies and proper equipment are available for safe and timely completion of the job task.
- Assign the duties of all members of the dive team and personally direct them throughout the diving operation.
- Personally verify that all personnel on the dive team are qualified and physically able to perform tasks assigned. He or she must make an assessment of the physical condition of the divers prior to each dive to determine if any physical impairment is present that would be detrimental to the divers' health and safety in the water or under hyperbaric conditions.
- Ensure that the diving equipment designated for use is:
  - Suitable for the planned diving operation.
  - Sufficient to regulatory requirements for the diving mode used.
  - Inspected prior to each dive and is in good working order.
- Ensure that all relevant operating instructions, manuals, decompression tables, treatment schedules and regulatory publications are available at the dive location and are maintained to reflect current changes and/or developments.
- Ensure the detailed briefing of his or her diving team and support personnel, including:
  - Tasks to be undertaken.
  - Unusual hazards or environmental conditions.
- Make modifications to standard procedures or safety procedures necessitated by the specific diving operation.
- Maintain a depth, bottom time and breathing mix profile at the dive location for each diver during the dive.
- Ensure that each diver is continuously tended while in the water.
- Ensure the dive is terminated when:
  - The diver requests termination.
  - The diver fails to respond to communication or communication is lost between the diver and dive team members at the dive location.
  - Communication is lost between the vessel operator and the diving supervisor during liveboating operations.
  - The diver begins to use his or her diver-carried reserve breathing gas supply.
  - Weather or site conditions are degrading to the extent that diver safety may be compromised.
- Ensure after every dive:
  - The physical condition and wellbeing of the diver is checked by visual observation and verbal questioning.
  - The diver is instructed to report any physical problems or symptoms of decompression sickness or arterial gas embolism.
  - The diver is advised of the location of the nearest operating decompression chamber and is acquainted with the dangers of flying after diving or traveling to altitudes higher than the dive site.
- Ensure after any treatment or dive outside the no-decompression limits:
  - The diver is instructed to remain awake and in the vicinity of a decompression chamber for at least one hour.
  - A trained dive team member is available to operate the decompression chamber.
- Report all accidents or incidents involving personnel as required by employer's rules and relevant governmental regulations.
- View and ensure accuracy of diver's personal log book and affix signature to properly record activities.
- Ensure prior to each bell run:
  - All bell checks are performed, internally and externally, and recorded.
  - All pertinent vessel or facility operators are properly notified.
  - All support equipment and personnel are prepared for the operation.
  - Clear communications are established with vessel operators, DP operators, ROV operators, crane operators and any other pertinent operational personnel.
- Ensure the bell run is terminated when:
  - Vessel is unable to or in danger of losing station keeping ability (weather or mechanical failure).
  - There is loss of hot water, gas, primary electrical power or any other life-support equipment
  - The atmosphere in the bell cannot be controlled (e.g., buildup of $CO_2$).
  - Weather, sea or external conditions endangering the bell.

- There is loss of clear communication with critical operation personnel such as the DP vessel operator on a DP diving vessel.
- There is loss of the DP alert system on a DP vessel.
- The DP officer issues a yellow or red light on a DP vessel.
- There is danger to topside crew preventing or degrading the performance of bell retrieval operations such as an approaching weather front or lightning.
- Primary communication with the bell is lost.
- There is a suspected or confirmed presence of hydrocarbon gas in the bell.
- Any time that the safety and wellbeing of the saturation divers warrants termination.

- Ensure after each bell run:
  - Any maintenance or repairs are performed to bring all redundant systems back on line.
  - Perform proper record keeping relative to LARS performance and upcoming maintenance issues.
  - Debrief deck crew regarding any issues encountered during bell recovery.
  - The deck foreman, LST and sat techs are fully aware of any maintenance or repair issues and preparations are being made to be ready for the next bell run.

### 3.8.2 QUALIFICATIONS AND CERTIFICATIONS

- All Dive Supervisors must be vetted by their employer and formally assigned in writing as a Dive Supervisor.
- Successful completion of the ADCI supervisor exam.
- ADCI supervisor certification card for the diving mode.
- Before being exposed to hyperbaric conditions, the supervisor must be medically certified as "fit to dive."
- Valid CPR and first aid certification.

### 3.8.3 CERTIFICATION CARD DESCRIPTION

**This type of card will be issued byADCI to certified divers who have:**

a. Successfully completed the ADCI bell/saturation diving supervisor's certification examination.
b Completed at least 100 field days as a mixed-gas diving supervisor.
c Performed for at least 60 days as an assistant bell/saturation diving supervisor.

### 3.8.4. CERTIFICATION CARD REQUIREMENTS

(Requirements located in Section 3.1.4: **Certification and Training Matrix**).

## 3.9 LIFE-SUPPORT TECHNICIAN

**All ADCI general member company diving personnel need to hold a current ADCI certification reflective of the assigned tasks to be performed.[2]**

### 3.9.1 RESPONSIBILITIES

The life-support technician is utilized in the saturation diving mode and reports directly to the diving supervisor. The life-support technician must possess the knowledge and ability to perform the duties listed below within the scope of the assignment.

This knowledge and skill will have been obtained by a combination of on-site experience and training. It is required that life-support technicians maintain a personal log book that includes the details of their work experience and qualifications. The duties and responsibilities of life-support technicians will vary depending on the diving mode employed, but at a minimum they shall control and constantly monitor the hyperbaric environment and system in which divers live while saturation diving. Their duties in this diving mode include, but are not limited to:

- Maintain proper atmosphere (e.g., correct levels of oxygen, carbon dioxide and other gasses) and pressure in the saturation complex according to employer's policy and as directed by the diving supervisor.
- Maintain proper environment (i.e., temperature and humidity) at levels suitable for current depth as the diver's comfort dictates.
- Decompress divers according to established schedules as directed by the diving supervisor.
- Maintain communication with divers.

- Calibrate, at regular intervals, all monitoring instruments that require, by their design, periodic calibration, or at any time the accuracy of the instrument is suspect.
- Maintain an accurate record of events, in the form of a saturation log, pertaining to the diving system. All readings taken and actions during the shift must be entered in the log.

The information in the saturation log shall include:

- Oxygen and carbon dioxide readings.
- Depth changes and temperature and humidity readings.
- Gas changes and BIBS usage details.
- Carbon dioxide scrubber changes.
- Medical lock runs, with record of items locked in or out.
- Individual diver's sleep cycles.
- Showers, flushes and drains.
- Calibration of instruments.
- Bell on and off systems and crew TUPs.
- Changes to settings on the environmental control system and record of equipment status.
- Chamber hygiene and disinfection and diver's ear prophylaxis.
- Any event outside normal chamber routines.
- Any articles entering the system.

- Maintain the diver's requirements within the diving complex. All matters that concern the diver's safety and well being are promptly carried out. These include such items as food, drinks, entertainment, personal hygiene, laundry and sanitary matters, etc.
- Be aware at all times of all items being sent in or out of the system, and supervise all such operations. Prevent prohibited items from entering the system.
- Advise the diving supervisor of the diver's status at regular intervals or as conditions dictate.
- Be alert for emergencies.
- Keep traffic in the control van to a minimum.
- Conduct such operations as may be required or directed by the diving supervisor.
- Perform assigned diving supervisor tasks. Be responsible to ensure that all gasses to be used during the dive have been properly analyzed and have been receipted for and logged in before being placed online.
- Maintain adequate supply of the correct breathing mixture to the diver.
- Maintain correct supply over-pressure for depth and apparatus.
- Have standby banks ready.
- Follow the tables in use correctly and accurately.
- Switch breathing mixtures at the proper time and depth.
- Record gas consumption data as directed.
- Assist in the maintenance of all diving equipment.
- Assist in the training of tender/divers and new personnel.
- Report any potentially unsafe situations or conditions to the diving supervisor.
- Maintain certification in first aid and CPR, and have a through working knowledge of emergency procedures and the diagnosis and treatment of decompression sickness.
- Be aware at all times of the actions carried out by personnel temporarily under his or her supervision. The life-support technician must be informed beforehand of any activity to be carried out on the diving complex, its support equipment, or in the near vicinity by other personnel.

### 3.9.2 QUALIFICATIONS AND CERTIFICATIONS

- Training and experience applicable to the equipment under their charge.

- A working knowledge and understanding of the physics and physiology of diving.
- Basic understanding of saturation theory and safe operations.
- Specific certification and training as required by industry, regulatory agencies and manufacturers.
- Valid CPR and first aid certification.

### 3.9.3 CERTIFICATION CARD DESCRIPTION

**This type of card will be issued by ADCI to personnel who have:**

a. Successful completion of the ADCI life-support technician exam
b. Performed at least 100 field days as an assistant life-support technician.

### 3.9.4. CERTIFICATION CARD REQUIREMENTS

(Requirements located in Section 3.1.4: **Certification and Training Matrix**).

## SECTION 4.0

# DIVING MODES: DEFINITIONS, REQUIREMENTS AND GUIDELINES

**Association of Diving Contractors International, Inc.**

# 4.0 GENERAL INTRODUCTION

**All equipment and personnel levels referenced in Section 4 should be considered the recommended minimum for approaching ALL diving applications, which is based on one dive and any applicable decompression required. Increased personnel levels and additional equipment may be required for any diving of more than one dive and any decompression required. Proper pre-job planning shall be conducted to ensure the necessary levels of personnel and equipment are available for diving operations. Additionally, all hazards shall be reviewed onsite, and appropriate changes made accordingly.**

Specific operations procedures vary with the type of diving mode employed. A project risk assessment/hazard identification process or dive plan shall be performed prior to mobilization to determine the type of diving mode to be employed, the equipment needed, and the job personnel requirements.

Before the commencement of any diving operation, the job hazard analysis shall be reviewed onsite with mitigations enhanced if conditions warrant. All dive team members, including the master of the vessel (as well as other involved personnel), shall be present at a pre-dive safety meeting.

## 4.1 SELF-CONTAINED DIVING (SCUBA)

SCUBA is an acronym for self-contained underwater breathing apparatus. Commercial SCUBA divers carry two sources of air (primary and emergency reserve) that allow underwater breathing. Many underwater inspections require using SCUBA equipment to access remote target work areas where a surface-supplied diving system would be impossible or dangerous. This section outlines the personnel requirements, limits, and procedures related to commercial SCUBA diving.

**SCUBA procedures should not be used for commercial diving operations except where they can be shown to be equally as safe or safer than surface-supplied air diving. The following are the minimum requirements for Commercial self-contained diving operations.**

**Recreational SCUBA diving courses at any level do not provide adequate training, nor are they recognized as commercial diving training. Therefore, each dive team member conducting Commercial SCUBA dives is required to have an ADCI certification card.**

### 4.1.1 MINIMUM PERSONNEL REQUIREMENTS

The minimum number of personnel comprising a SCUBA dive team is never less than four. However, planning must consider not only the direct requirements of the work to be performed but also additional known or suspected factors that may lead to complications during the conduct of the intended operation. Merely because a dive team comprised of four persons may be adequate during one operation does not mean the same number of persons will be enough to accommodate the requirements of a different operation.

*Commercial tethered SCUBA diving 0-100 fsw (0-30 m) with no decompression:*

- One diving supervisor.
- One diver line tethered to the surface with communications.
- One tethered standby diver with communications shall be properly equipped and capable of performing the duties of a standby diver.
- One tender.
- All members of the team on the surface must be qualified first aid, CPR, and O2 providers or Diving Medical Technicians (DMT).

*Commercial untethered SCUBA diving 0-100 fsw (0-30 m) with no decompression:*

- One diving supervisor.
- Two Divers.
- One tethered standby diver with communications shall be properly equipped and capable of performing the duties of a standby diver.
- All members of the team on the surface must be qualified first aid , CPR, and 02 providers or Diving Medical Technician (DMT).

**NOTE:** *<u>Any deviation</u> from the personnel requirements requires a change to the dive plan, and the JSA/HSA must be reviewed for possible changes.*

### 4.1.2 OPERATIONAL GUIDELINES

**Minimum Operating Requirements (SCUBA Imperatives)**

1. SCUBA dives shall not be conducted against currents exceeding one (1) knot or 1.6 ft. per second.
2. SCUBA dive depths shall not exceed 100 fsw (30 msw) or no decompression limits.
3. The planned time of a SCUBA diving operation shall not exceed the no decompression limits or the limits of the diver's planned air supply duration.
    - Emergency gas supply (bailout) shall always have a minimum calculated Five-minute supply at the planned deepest depth of the dive.
4. Scuba divers shall be equipped with a diver-carried primary and emergency air supply routed through a switch/manifold block
5. Cylinder (primary emergency) pressure shall be determined immediately before each dive.
    - Both sources shall be equipped with separate submersible pressure gauges.
6. SCUBA divers shall have voice communications between each other and the surface at all times.
7. SCUBA penetration dives are strictly prohibited. SCUBA shall not be conducted in enclosed or physically confining spaces or where the diver does not have direct surface access.
8. SCUBA dives shall not be conducted in areas where pressure differentials exist or are suspected.
9. During all SCUBA dives, a tethered standby diver with communications shall be available while a diver(s) is in the water.
10. SCUBA divers shall be line-tended from the surface or accompanied by another diver in the water in continuous visual or physical contact during the diving operations.
11. Diving on SCUBA should only be allowed during daylight hours.
12. All divers on SCUBA shall wear a buoyancy compensator that provides a minimum of 10 lbs of positive buoyancy at the maximum depth, a power inflation source, and an oral inflation source. Divers shall be equipped with a whistle or other audio signaling devices.
13. The diver shall also carry a lighted beacon during low or poor surface visibility circumstances.
14. Tools powered by hydraulics, air, or batteries shall not be used while conducting commercial SCUBA diving.
15. Inspection instruments such as cathodic protection probes and ultrasonic thickness meters are allowed.
16. Nitrox diving is only permitted when a recompression chamber is on site. The entire team is properly trained and equipped for Nitrox diving. The diving supervisor must have ADCI Nitrox endorsement.
17. Commercial SCUBA is strictly prohibited on an active construction site.

**Diver worn/carried emergency gas supply (bailout) must have a minimum calculated five-minute supply at the anticipated depth.**

### 4.1.3 MINIMUM EQUIPMENT REQUIREMENTS

1. Each diver shall be equipped with a knife, diving wristwatch and depth gauge.
2. A buoyancy compensator device (BCD) providing a minimum of 10 lbs buoyancy at maximum depth with a power inflator and oral inflator.
3. Divers shall be equipped with a whistle or other audio signaling devices.
4. Two cylinders one that meets the air consumption requirements for the planned dive and one of which has a minimum five-minute air supply at the planned deepest depth of the dive.
5. Two first-stage regulators (primary and emergency)
    - Each regulator shall have an over-pressure relief valve.
    - The primary regulator shall have an inflator whip connected to BCD and a dry suit if applicable.
    - Each regulator shall be equipped with a separate submersible pressure gauge
6. Each diver will be equipped with a Gas switching/manifold block.
7. Full face masks with either
    - Through water communication to the surface (supervisor), with diver-to-diver communications
    - Tethered Communications to surface (supervisor).

8. A weight belt with a quick release or a BCD with integrated detachable weights appropriate for the suit and depth of the dive shall be worn.
9. An emergency $0_2$ administration kit an approved ADCI first aid kit and a floating back board or stokes litter with head and neck restraint. (Readily available for the treatment of diver{s}).

## 4.2 SURFACE-SUPPLIED AIR DIVING

**When two divers are working simultaneously from a single dive station, an additional standby diver and topside tender are required. All equipment and manning levels should be considered the recommended minimum for approaching this diving application, based on one dive and any applicable decompression required. Increased manning levels and additional equipment may be required for any diving in excess of one dive and any decompression required. Proper pre-job planning shall be conducted to ensure that the necessary levels of personnel and equipment are available for diving operations.**

**At no time shall any member of the dive team be asked to perform an activity that prevents that person from the immediate and continuous performance of dive supervisor's assigned duties and responsibilities.**

**During the planning phase of the intended operation, a Job Hazard Analysis (JHA) should be conducted to ensure that all factors necessary to support the highest levels of safety have been considered. The JHA should include a method for the safe recovery of an incapacitated diver.**

**At least one qualified dive team member assigned to each dive crew must be fully competent, equipped and designated to perform the duties of a standby diver in order to render emergency assistance to a regularly assigned diver. If the nature of the work does not subject the second diver in the water to the same hazard as the primary diver, (e.g., deep ditch cave in from hand jetting, etc.), the second diver in the water can serve as the standby diver. Additionally, the second/standby diver must remain in close proximity to the primary diver. NOTE: EACH WORKING DIVER MUST BE CONTINUOUSLY TENDED BY A SEPARATE DIVE TEAM MEMBER.**

**Individuals other than a member of the dive team may be used to physically tend cables and/or lines entering the water. These individuals must at all times be immediately responsive to direction from the diving supervisor or designated person in charge.**

**Volume tanks are only required for air dives or chamber operations utilizing an LP compressor. Operations utilizing only HP/ bottled air supplies do not require a volume tank.**

**If diving operations are conducted in a physically confining space, refer to Penetration Diving in Section 5.**

### 4.2.1 SURFACE-SUPPLIED AIR DIVING 0-100 fsw (0-30 msw) WITH NO DECOMPRESSION

The following are minimum requirements for surface-supplied air diving operations:

1. Minimum Personnel

At a minimum, at least one member of the dive team must have a recognized $O_2$ provider certification or be a DMT. If that member is a part of the dive rotation, then at least two members of the dive team must have a recognized $O_2$ provider certification or be DMTs.

The minimum number of personnel comprising a dive team is never less than three; however, planning must take into consideration not only the direct requirements of the work to be performed, but also additional factors either known or suspected that may lead to complications during the conduct of the intended operation. Merely because a dive team comprised of three persons may be adequate during one operation does not mean the same number of persons will be sufficient to accommodate the requirements of another operation.

**Diving contractor management and diving supervisors must carefully consider manning levels of the dive team. Although regulations may permit diving with a minimum crew of three persons, that level of manning is strictly under optimal conditions. For example, any time commercial diving operations are intended to take place in a remote location, or where an air gap from the diving station to the water exceeds 15 feet (4.6 m), at least a fourth member of the dive team should be considered.**

**Shallow Operations with Large Crews**

**When a diving operation takes place in less than 100 fsw (30 msw) and the on-shift crew size is eight or more, then a diving supervisor who is not part of the diving rotation must be part of the crew.**

### 4.2.1.1 Minimum Personnel Requirements

- One air-diving supervisor.
- One diver.
- One tender/diver who shall be properly equipped and capable of performing the duties of a standby diver.
- All members of the team on the surface must be qualified first aid, CPR, and O2 providers or Diving Medical Technicians (DMT).

**a. Diving Supervisor**

- A qualified person shall be designated as the diving supervisor for each diving operation. The diving supervisor is in charge of the planning and execution of the diving operation, including the responsibility for the safety and health of the dive team.
- The diving supervisor shall possess the proper ADCI supervisor certification card 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**

Must have training and/or experience in the following areas:

- Air-diving procedures and techniques.
- Emergency procedures.
- Diving accident treatment procedures.
- Proper operation and use of all equipment related to air diving including decompression chambers.
- Use of air-diving equipment
- Familiarity with the type of work engaged in.

**c. Tender/Diver**

- Must have the same qualifications as an Air Diver, with a lower level of experience required.

NOTE: An additional dive crew member is normally required when any diving operation is conducted that has an increased likelihood of diver entrapment or potential for rendering the diver unconscious or incapacitated from chemical, physical, electrical or topside hazards, such as, but not limited to, the following when present or planned:

- 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. 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.
- Diving in remote locations where assistance from non-diving crew personnel is not immediately available within communication range of the diving supervisor may require additional members to be added to the dive team.

### 4.2.1.2 Operational Guidelines

1. The approximate 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. When using mixed gas or enriched air, all gasses must be analyzed before they goes on-line for $O^2$ content and for proper mixture necessary to support the maximum depth of the planned dive.
3. Each diver shall be continuously tended while in the water by a separate dive team member.
4. Each diving operation shall have a primary breathing gas supply sufficient to support all divers for the duration of the planned dive, including decompression.
5. If no decompression chamber is on site, the nearest manned operational chamber should be known, and an evacuation plan should be in place.

### 4.2.1.3 Minimum Equipment Requirements

- Emergency 02 kit is required to contain at a minimum: An 02 cylinder (with current hydro) containing a minimum of 30 minutes 02 at a rate of 15 liters per minute (lpm). The system must contain a pocket mask with an 02 inlet, a non-rebreather mask, and a demand inhalator and/or demand resuscitator.
- The system must contain a pocket mask with an O2 inlet and non-rebreather mask.
- 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.
- Two time-keeping devices.
- One basic first aid kit with means of manual resuscitation (pocket mask or others). Local regulatory authorities may require additional equipment and training
- Emergency $O_2$ administration kit.
- 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.
- Spare parts as required.
- Dive sheets, safe practices manual, first aid handbook and written JHA applicable to job.

## 4.2.2 SURFACE-SUPPLIED AIR DIVING 0-100 fsw (0 – 30 msw) WITH PLANNED DECOMPRESSION

### 4.2.2.1 Minimum Personnel Requirements

- One air-diving supervisor.
- One diver.
- One standby diver.
  - Two tender/divers.
  - All members of the team on the surface must be qualified first aid, CPR, and O2 providers or Diving Medical Technicians (DMT).

**a. Diving Supervisor**

- A qualified person shall be designated as the diving supervisor for each diving operation. The diving supervisor is in charge of the planning and execution of the diving operation, including the responsibility for the safety and health of the dive team.
- The diving supervisor shall posses the proper ADCI supervisor certification card 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**

Must have training and/or experience in the following areas:

- Air diving procedures and techniques.
- Emergency procedures.
- Diving accident treatment procedures.
- Proper operation and use of all equipment related to air diving, including decompression chambers.
- Use of air diving equipment.
- Familiarity with the type of work engaged in.

**c. Tender/Diver**

- Must have the same qualifications as an Air Diver, with a lower level of experience required.

#### 4.2.2.2 Operational Guidelines

1. The approximate depth of each dive shall be determined prior to the start of operations.
2. All breathing media other than air shall be verified for proper composition prior to being placed on-line.
3. A decompression chamber shall be ready for use at the dive location and accessible by the diver within the allowed time frame as prescribed by the decompression schedule.
4. Each diver shall be continuously tended while in the water by a separate dive team member.
5. Each diving operation shall have a primary breathing gas supply sufficient to support all divers for the duration of the planned dive, including decompression, as well as a secondary independent breathing gas supply.

#### 4.2.2.3 Minimum Equipment Requirements

- Two independent air sources (and volume tanks if applicable) to support two divers.
- Dive station emergency air source.
  - One double-lock decompression chamber and adequate air source to recompress the chamber to 165 fsw.
  - Adequate supply of gasses for the planned dive profile and a potential treatment.
- 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.
- For planned in-water decompression:
  - Third source of diver's emergency air supply, in addition to diver's umbilical and EGS.
- 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.
- Two time-keeping devices.
  - One basic first aid kit with bag-type manual resuscitator with transparent mask and tubing.
- Two sets of diver's personal diving equipment consisting of:
  - Helmet or mask.
  - Diver-worn EGS.
  - Weight belt if needed.
  - Protective clothing.
  - Tools as required.
  - Safety harness.
  - Knife.
  - Spare parts as required.
  - Dive sheets, safe practices manual, first aid handbook and written JHA applicable to job.

### 4.2.3 SURFACE-SUPPLIED AIR DIVING 101-190 fsw (30 – 57 msw)

#### 4.2.3.1 Minimum Personnel Requirements

- One air-diving supervisor.
- One diver.
- One standby diver.
- Two tender/divers.
- All members of the team on the surface must be qualified first aid, CPR, and O2 providers or Diving Medical Technicians (DMT).

**a. Diving Supervisor**

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

The diving supervisor shall posses the proper ADCI supervisor certification card 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**

Must have training and/or experience in the following areas:

- Air diving procedures and techniques.
- Emergency procedures.
- Diving accident treatment procedures.
- Proper operation and use of all equipment related to air diving, including decompression chambers.
- Have experience in the use of air diving equipment.
- Familiarity with the type of work engaged in.

**c. Tender/Diver**

- Must have the same qualifications as an air diver, with a lower level of experience required.

### 4.2.3.2 Operational Guidelines

1. The approximate 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 gases that is appropriate for the depth of the dive. When using mixed gas or enriched air, all gasses must be analyzed for proper mixture necessary to support the maximum depth of the planned dive or decompression.
3. A decompression chamber shall be ready for use at the dive location and accessible by the diver within the allowed time frame as prescribed by the decompression schedule.
4. Each diver shall be continuously tended while in the water by a separate dive team member.
5. Each diving operation shall have a primary breathing gas supply sufficient to support all divers for the duration of the planned dive, including decompression.

### 4.2.3.3 Minimum Equipment Requirements

- Two independent air sources and volume tanks to support two divers.
- Dive station emergency air source.
- One double-lock decompression chamber and adequate air source to recompress the chamber to 165 fsw.
- Adequate supply of gasses for the planned dive profile and a potential treatment.
- Two hose groups consisting of:
  - Air hose.
  - Diver-worn EGS
  - Strength member/strain relief. (The strength member may be the entire hose assembly, if so designed.)
  - Communications cable.
  - Pneumofathometer hose.
- One set of decompression and treatment tables.
- For planned in water decompression:
  - One diving stage or other support platform.
  - Third source of diver's emergency air supply, in addition to diver's umbilical and EGS.
- 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.
- Two time-keeping devices.
- One basic first aid kit with bag-type manual resuscitator with transparent mask and tubing.
- Two sets of diver's personal diving equipment consisting of:

- Helmet or mask.
- Weight belt if needed.
- Protective clothing.
- Tools as required.
- Safety harness.
- Knife.

- Spare parts as required.
- Dive sheets, safe practices manual, first aid handbook and written JHA applicable to job.

## 4.3 ENRICHED-AIR DIVING (NITROX)

### 4.3.1 DEFINITION

Nitrogen-oxygen diving (also called enriched-air or NITROX diving) is a technique whereby the $O_2$ percentage in the breathing mixture is elevated above 21 percent, and the balance of $N_2$ is reduced proportionately. Due to the reduction in the nitrogen content in the breathing mixture, a diver may work deeper or longer without decompression than a diver breathing air and maintain the same $N^2$ uptake.

Advantages of nitrogen-oxygen (NITROX) diving over air diving:

- Extended bottom times for no-decompression diving.
- Reduced decompression time.
- Reduced residual nitrogen in the body after a dive.
- Reduced possibility of decompression sickness.
- Reduced nitrogen narcosis.

The disadvantages include:

- Increased risk of CNS oxygen toxicity.
- Long duration dives can result in pulmonary oxygen toxicity.

NITROX is most effective in shallow water with a maximum depth of 100 feet. It can significantly extend bottom time depending on the depth used.

### 4.3.2 GENERAL

**When two divers are working simultaneously from a single dive station, an additional standby diver and topside tender are required.**

The use of NITROX for diving operations has become a routine and accepted practice to improve divers' safety and the effectiveness of diving operations. While the benefits of using NITROX can be significant, the use of any breathing gas in lieu of naturally occurring air brings with it hazards that must be addressed prior to the start of any diving operation.

Dives using NITROX may be used with any schedule from the U. S. Navy Air Decompression tables. Surface decompression using oxygen is not recommended when diving NITROX due to the increased uptake of oxygen during decompression. Should Sur D $O^2$ be used, particular attention must be given to total oxygen uptake when planning the dive profile.

When selecting the proper NITROX mixture, considerable caution must be used. The maximum depth of the dive must be known as well as the planned bottom time. If a diver's depth and time profile exceeds that allowed for a certain NITROX mixture, the diver is at a greater risk of life-threatening CNS oxygen toxicity as well as the longer-term effects associated with pulmonary oxygen toxicity. The NOAA Dive Manual provides maximum single and 24-hour exposure times for $PPO_2$ ranges of 0.6 to 1.6. These times must not be exceeded.

#### EQUIVALENT AIR DEPTH (EAD)

EAD is an accepted form of calculating the diver's equivalent air depth based on the amount of nitrogen in the diving breathing mix. EAD is then used to determine the proper depth profile when selecting the U.S. Navy Air No-Decompression or Air Decompression Table.

EAD may also be tabulated using a look-up table. The NOAA Dive Manual provides equivalent air depths for oxygen percentages between 28 and 40 percent. The U. S. Navy Diving Manual provides equivalent air depths for oxygen percentages from 25 percent to 40 percent.

The EAD is calculated using the formula:

$$EAD = \left(\frac{FN_2}{0.79} * (d + x)\right) - x$$

Another form of the equation can be shown as:

$$EAD = \left(\frac{FN_2 * (d + x)}{0.79}\right) - x$$

Where:

- FN2 is the fraction of nitrogen in the nitrox mix.
- 0.79 is the fraction of nitrogen in air (including the trace gases).
- d is the actual depth in the appropriate units (fsw or msw).
- x is the depth of water equivalent to 1 Bar in the appropriate units (33 fsw or 10 msw).

Using an EAD enables dives on nitrox to be planned using standard air tables. When diving on air, the EAD is the actual depth. On a hypoxic mix (<21 percent $O_2$), the EAD would be deeper than the actual depth. On a hyperoxic mix (>21 percent $O_2$), the EAD will be shallower than the actual depth.

### 4.3.3 REQUIREMENTS

The following requirements, when used with U.S. Navy Air Decompression tables, will greatly reduce the risk to the diver from CNS oxygen toxicity and pulmonary oxygen toxicity.

1. During all diving operations, the diver's on-line gas supply is to be continuously analyzed for $O_2$ content, with Hi/Lo audio/visual alarms armed if available.
2. Diver's oxygen exposure times shall be tracked for both single exposure and daily dose maximums. It is recommended that the NOAA Oxygen Exposure Chart of the NOAA Dive Manual or equivalent be utilized.
3. Maximum oxygen percentage of the NITROX mix shall be 40 percent (except when used as a decompression or therapeutic media).
4. All NITROX gasses shall be within ± 1 percent of the certified mixture.
5. During all diving operations, there will be a back-up supply of an appropriate NITROX mix online to the diver's gas supply panel, and if a third supply is deemed necessary, this may be air or NITROX. Any stage gas will also contain the same NITROX mix as the diver is breathing.
6. Divers shall wear bailout bottles at all times. The diver's bailout bottle shall be charged with the same NITROX mixture as the primary supply, tested and properly labeled.
7. Although there are a number of variables to take into consideration in the event the diver does breathe air under pressure during the dive (e.g., incorrect gas mixture on line), the following is to be strictly adhered to:

**Abort the dive and decompress the diver as though he or she had breathed AIR throughout the entire dive <u>at the actual depth of the dive (not the EAD).</u>**

8. Dives shall be planned so that, should a diver be switched to compressed air at any time during the dive, his or her decompression commitment will not exceed the operational planning limits of an air-dive at that depth.
9. When using U.S. Navy tables, round all gas mixtures using the standard rounding rule: where gas mixes at or above 0.5 percent, round up to the next whole percent; and for mixes of 0.1 percent to 0.4 percent, round down to the next whole percent.

### 4.3.4 TRAINING

All diving supervisors and divers associated with any commercial diving operation using NITROX shall be trained according to an accepted diving industry standard. Recreational training standards by themselves are not considered adequate for commercial operations. All training must be fully documented. All ADCI Certified Supervisors must take the NITROX ENDORSEMENT exam to supervise NITROX diving operations. The specific training shall include the following topics:

- Definition of nitrox.
- Historical perspective.
- Advantages and limitations.
- Gas laws and calculations.
- Equivalent air depth formulas and tables.

- Physiological aspects of oxygen.
- Gas supply and analysis.
- Equipment considerations.

## 4.3.5 OPERATIONAL PROCEDURES

### 4.3.5.1 Repetitive Dives

Repetitive dives may be performed using EAD and the U.S. Navy Air Decompression schedules. Once EAD is determined for a specific dive, the Standard Navy Air tables are used throughout the dive using the EAD.

### 4.3.5.2 Diving at Altitude

NOAA NITROX diving tables are useable to 1,000 ft. elevation. At higher elevations, use EAD corrected to seal-level equivalent depth per U. S. Navy Dive Tables tables.

### 4.3.5.3 Omitted Decompression

Follow procedures outlined in the U. S. Navy Dive Manual.

### 4.3.5.4 Decompression Chamber Requirement

On all dives where decompression is planned, or deeper than 100 feet, or liveboating deeper than 60 feet, a fully operational decompression chamber will be required to be on site.

## 4.3.6 GAS SUPPLIES

### 4.3.6.1 NITROX Breathing Gas Certifications and Labeling

All NITROX gas containers shall be certified as to the $N_2O_2$ mixture by the vendor or dive contractor supplying the gas and be clearly marked by gas mixture percentage on each container.

### 4.3.6.2 NITROX Mix Testing

Each container of NITROX being placed on-line in support of diving operations must be tested with a calibrated oxygen analyzer by the diver or diving supervisor to confirm gas mixture prior to use

(on-line at the point of distribution-manifold).

### 4.3.6.3 NITROX Mix Tolerance

All NITROX gasses shall be within +/- 1 percent of the certified mixture.

### 4.3.6.4 Breathing Gas Purity

Nitrogen or air must be filtered prior to being mixed with oxygen. It is essential that all gasses used in producing a NITROX mixture meet the breathing gas purity standards for oxygen and nitrogen. If air is to be used to produce a mixture, it must meet the purity requirements of oil-free air (oil mist limit 0.1 mg/m3).

### 4.3.6.5 Cleaning for $N_2O_2$ Service

Cleanliness and the procedures used to obtain and maintain cleanliness are a concern with NITROX systems. Current NOAA, OSHA and USCG guidelines allow gas mixes with oxygen up to 40 percent to be handled as if they were air, and the commercial industry routinely uses up to 50 percent $O_2$ at low delivery pressures without formal $O_2$ cleaning. However, it is recommended that all equipment be cleaned of any visible debris, then scrubbed manually or cleaned ultrasonically with a strong detergent in hot water, then rinsed several times in clean hot water.

## 4.3.7 THERAPEUTIC PROCEDURES

In the event therapeutic treatment is required following an NITROX dive, the same procedure will be followed as though the diver had made an air dive.

**NOTE: The diver's $O_2$ uptake must be tracked closely should an $O_2$ treatment table be used.**

*Primary Reference Documents:*

- Current U.S. Navy Diving Manual
- Current U.S. Department of Commerce NOAA Dive Manual

# 4.4 SURFACE-SUPPLIED MIXED-GAS DIVING ($HeO_2$)

**All equipment and manning levels should be considered the recommended minimum for approaching this diving application, based on one dive and any applicable decompression required. Increased manning levels and additional equipment may be required for any diving in excess of one dive and any decompression required. Proper pre-job planning shall be conducted to ensure that the necessary levels of personnel and equipment are available for diving operations.**

The following are minimum requirements for surface-supplied mixed-gas ($HeO_2$) diving operations:

## 4.4.1 MINIMUM PERSONNEL REQUIREMENTS

- One mixed-gas diving supervisor (not part of the dive rotation).
- One diver.
- One standby diver.
- Two tender/divers.
- All members of the team on the surface must be qualified first aid, CPR, and O2 providers or Diving Medical Technicians (DMT).

## 4.4.2 OPERATIONAL GUIDELINES

1. The appropriate depth of each dive shall be determined prior to the start of operations. Set maximum depth at 300 fsw (91msw).
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. When using mixed gas, all gasses must be analyzed for $O_2$ content and for proper mixture necessary to support the maximum depth of the planned dive.
3. A decompression chamber shall be ready for use at the dive location and accessible by the diver within the allowed time frame as prescribed by the decompression schedule.
4. Each diver shall be continuously tended while in the water by a separate dive team member.
5. A diver shall be stationed at the underwater point of entry when diving is conducted in an enclosed or physically-confining space.
6. Each diving operation shall have a primary breathing gas supply sufficient to support all divers for the duration of the planned dive, including decompression.
7. $HeO_2$ dives require a designated manifold operator.

**Any operation deeper than 165 fsw requires a method for mitigating the uncontrolled ascent of a diver to the surface. This can come in the form of clipping in the diver's umbilical to the stage or bell, or the use of a "golden gate" apparatus.**

## 4.4.3 MINIMUM EQUIPMENT REQUIREMENTS

**All $HeO_2$ operations will require an open bell. In the event that an open bell cannot be deployed due to confined space or accessibility, an alternate supply of emergency gas, excluding the diver's umbilical, shall be supplied.**

- Two gas sources to support two divers (Including planned decompression).
- Readily available dive station emergency gas source.
- One double-lock decompression chamber and adequate air source to recompress the chamber to 165 fsw.
- Adequate supply of oxygen for the planned dive profile and a potential treatment.
- Two umbilical groups (reference Section 6: Hoses).
- One set of decompression and treatment tables.
- One open bottom bell and umbilical and launch recovery system with a secondary means of bell recovery for all operations.
- One control station consisting of:
  - Appropriate communication systems with back up (helium scrambler recommended).
  - Depth gauges and gas distribution system with the capability to supply and control two divers and the open bottom bell at the maximum work depth.
- An oxygen analyzer fitted in-line on the downstream gas supply to diver(s) shall have a hi/low visual and/or audio alarms[2].
- Two time-keeping devices.

- One basic first aid kit with bag-type manual resuscitator with transparent mask and tubing.
- Two sets of diver's personal diving equipment consisting of:
  - Helmet or mask.
  - Weight belt if needed.
  - Protective clothing.
  - Tools as required.
  - Safety harness.
  - Knife.
- Spare parts as required.
- Dive sheets, safe practices manual, first aid handbook and written JHA applicable to job.
- Diver-worn EGS

## 4.5 SATURATION DIVING

**All equipment and manning levels identified should be considered the recommended minimum for approaching this diving application, based on one dive and any applicable decompression required. Increased manning levels and additional equipment may be required for any diving in excess of one dive and any decompression required. Proper pre-job planning shall be conducted to ensure that the necessary levels of personnel and equipment are available for diving operations.**

The following are minimum requirements for saturation diving operations (based upon 24-hour operations and a single bell run). On multi-day projects, consideration should be given to the number of divers in saturation and the maximum bell run duration to ensure adequate rest and to avoid fatigue.

### 4.5.1. MINIMUM PERSONNEL REQUIREMENTS

- Two bell/saturation supervisors.
- Two saturation divers.
- Two surface standby divers (saturation qualified).
- Two life-support technicians.
- Two saturation technicians.
- Four tender/divers.
- All members of the team on the surface must be qualified first aid, CPR, and O2 providers or Diving Medical Technicians (DMT).

**(With the exception of the supervisors and technicians, one member of the dive team should be a diver medical technician or equivalent.)**

### 4.5.2. OPERATIONAL GUIDELINES

**All saturation diving operations shall have a reserve volume of gas stored at the dive site equivalent to 1.5X the volume required to pressurize the system to deepest planned working dive, after the system is pressurized.**

1. The approximate depth of each dive shall be determined prior to the start of operations.
2. A surface standby diver shall be available when the closed bell leaves the dive location until the divers are in the saturation deck chamber.
3. All closed bell operations (lock-off to lock-on) will be conducted with a minimum of two-man bell runs.
4. Independent primary and secondary supplies of gasses shall be provided for the working diver and the bell diver gas sources and volume tanks to support two divers.
5. A copy of the emergency tap code shall be available to the bell occupants and dive control station personnel.
6. There shall be a means and procedure to evacuate divers under pressure during an emergency.
7. The breathing mixture supplied to the diver must be composed of a mixture of gasses that is appropriate for the depth of the dive. When using mixed gas, all gasses must be analyzed for proper mixture necessary to support the maximum depth of the planned dive.
8. A decompression chamber for the surface standby diver shall be ready for use at the dive location and accessible by the diver within the allowed time frame as prescribed by the decompression schedule.
9. There must be a secondary means to recover the bell.

10. There must be a means to monitor the bell atmosphere for hydrocarbons or other contaminants.
11. A means of decontaminating the diver and/or bell atmosphere is required.
12. There must be a way of removing an incapacitated diver from the water into the bell.
13. Humidity and atmosphere shall be controlled and monitored.
14. Hot water temperature and flow to the diver and inside bell heater must be controlled.
15. The working diver shall be tended from the bell by the standby bellman/saturation diver.
16. A diver-worn emergency gas supply (bailout) shall be utilized (reference Section 6: Diver-worn Emergency Gas Supply).

### 4.5.3. MINIMUM EQUIPMENT REQUIREMENTS

- All PVHO shall be designed and constructed to local regulatory codes and standards.
- LARS and a secondary system to recover the bell.
- All LARS winches with redundant power supply.
- Redundant independent power supplies for system, control console and environmental controls.
- Secondary means to control environmental system.
- All equipment required for surface mixed-gas diving operations.
- Emergency evacuation system ( e.g., HRC or SPHL ), in addition to the primary bell.[3]
  (Also see Section 6.12.3 EMERGENCY EVACUATION SYSTEMS (EES))

**See Saturation Diving Inspection and Checklist Protocol in Section 10: ADCI COMPLIANCE AUDIT PROCEDURES for further details on minimum equipment requirements for saturation diving systems.**

# SECTION 5.0

# UNDERWATER OPERATIONS: PROCEDURES, CHECKLISTS AND GUIDELINES

**Association of Diving Contractors International, Inc.**

# 5.0 UNDERWATER OPERATIONS: PROCEDURES, CHECKLISTS AND GUIDELINES

## 5.1 SAFE PRACTICES/OPERATIONS MANUAL

1. Each contractor and school shall develop and maintain a safe practices/operations manual as required by applicable government regulations and the ADCI and shall make this manual available at the dive location to each dive team member. This manual must provide for the safety and health of the divers. Associate Member Schools are required to have their own version of a Safe Practices & Operations Manual, specific to the safety of both the students and instructors. The manual shall be available at the dive location or at each dive station at the school. The safe practices/operations manual shall meet or exceed the requirements of the ADCI International Consensus Standards for Commercial Diving and Underwater Operations.
2. The ADCI International Consensus Standards for Commercial Diving and Underwater Operations may be used as a set of minimum guidelines to assist contractors/schools in developing their own specific safe practices/operations manual. Each contractor/school is responsible for completing, modifying and/or complementing any of the procedures, checklists and standards in accordance with applicable governmental regulations and as dictated by specific policies and practices of the contractor/school.
3. The safe practices/operations manual shall, at a minimum, contain the following information:
   a. A copy of applicable government regulations for the conduct of commercial diving or other underwater operations.
   b. For each diving mode engaged in:
      I. Safety procedures and checklists for commercial diving operations.
      II. Assignments and responsibilities of dive team members.
      III. Equipment procedures and checklists.
      IV. Emergency procedures for fire, equipment failure, adverse environmental conditions, medical injury and illness.
4. The ADCI strongly recommends that each safe practices/operations manual contain a definitive statement regarding the use of drugs or alcohol. Such language should include references to applicable governmental regulations regarding drug and alcohol use in the work place. Additionally, such a statement should reference the employer's ADCI-required drug and alcohol program (reference Section 5.3: Drug and Alcohol Screening).

## 5.2 EMERGENCY AID

1. Each contractor/school shall develop and maintain a list of the available sources of emergency aid, equipment and professional assistance with call signs, phone numbers or other means and instructions for establishing contact with them for locations where operations are conducted. The hours of operation of the nearest hyperbaric facility, along with its chamber capability, i.e. 6 ATA or 165'.
2. Each contractor/school shall make the contact list available at the company's principal place of business, at the field operations office and to those who may have a need for it to fulfill the company's emergency response plan.
3. The list shall include information necessary to obtain the following types of emergency aid as appropriate for the type of diving or underwater activity conducted:
   - Decompression chamber to accommodate U.S. Navy Treatment Table 6.
   - Hospital or medical treatment facility.
   - Air or ground transportation.
   - On-call physician that is knowledgeable of the type of diving operation conducted to treat for potential diving-related illnesses.
   - Coast Guard or other national Rescue Coordination Centers.
4. Two-way communications shall be available and accessible at any diving, hyperbaric or other underwater work site in order to engage emergency services as required.

## 5.3 DRUG AND ALCOHOL SCREENING

1. A pre-employment drug screening program shall be in place.
2. A routine, random and "for cause" drug screening program shall be in place.

## 5.4 FIRST AID

1. First aid supplies appropriate to the type of operation being conducted shall be provided and kept readily accessible in a clearly marked container at the work site.
2. In addition to any other first aid supplies and standard first aid handbook (or equivalent), a means of manual resuscitation (pocket mask or others) is required. Local regulatory authorities may require additional equipment and training (e.g., emergency O2 administration kit).
3. A recommended list of the contents for a first aid kit is set forth below to reflect what should be considered the **minimum** contents. Each operator should review this list and make additions or substitutions as necessary to ensure that effective and timely first aid can be furnished.
4. Documented inspection of first aid kit contents is required annually.

**INVENTORY:**

**ADCI BASIC FIRST AID KIT (COMMERCIAL DIVING)**

| PRODUCT NAME | SIZE | QUANTITY |
|---|---|---|
| Contents Card | Each | 1 |
| Physician Approval Letter | Each | 1 |
| Seahorse Case 630 | Each | 1 |
| WOUND CARE | | |
| Band Aid Assorted Fabric | Each | 100 |
| Burn Dressing 4” x 4” | Each | 1 |
| Conforming Gauze 2” | Each | 2 |
| Conforming Gauze 4” | Each | 2 |
| Cotton Pads | Each | 10 |
| Cotton Tipped Applicators 3” | 100 | 1 |
| Elastic Bandage 4” | Each | 2 |
| Eye Pad Large | Each | 6 |
| Gauze Pads 2” x 3” | Each | 8 |
| Gauze Pads 3” x 4” | Each | 5 |
| Sam Splint | Each | 1 |
| Trauma Dressing 8” x 10” | Each | 4 |
| Tape Waterproof 3 in 1 | Each | 1 |
| Triangular Badge | Each | 3 |
| EMERGENCY | | |
| Airway Kit Guedel sizes 00-4 | Each | 1 |
| CPR Pocket Mask | Each | 1 |
| Resuscitator Bag Valve Mask with Mask & Tubing | Each | 1 |
| SKIN PREPARATIONS | | |
| BZK Antiseptic Towelettes | Each | 10 |
| Burn Free Gel U/D | Each | 6 |
| Eye Cup Plastic | Each | 1 |
| Eye Wash | 120ml | 1 |
| Hydrocortisone 1% Cream U/D | Each | 10 |
| Hydrogen Peroxide Solutions | 120ml | 1 |
| Povidone Iodine Swabsticks | Each | 10 |
| Triple Antibiotic Ointment U/D | Each | 10 |

| PRODUCT NAME | SIZE | QUANTITY |
|---|---|---|
| INSTRUMENTS & MEDICAL APPLIANCES | | |
| Biohazard Bag 23” x 23” | Each | 4 |
| Instant Cold Compress 5” x 7” | Each | 2 |
| First Aid Booklet | Each | 1 |
| Forceps Splinter 3.5” | Each | 1 |
| Gloves Nitrile Large | 1 Pair | 6 |
| Safety Pins Large | 12 | 1 |
| Trauma Shears | Each | 1 |
| For-purpose manufactured tourniquet | Each | 1 |
| MEDICATIONS | | |
| Acetaminophen 325mg U/D Tablets | Each | 10 |
| Alka Seltzer Tablets | 12 | 1 |
| Ammonia Inhalants | 10 | 1 |
| Antacid Calcium Supplement | 150 | 1 |
| Aspirin 325mg U/D Tablets | Each | 10 |
| Bismuth Chewable Tablets (Pepto Bismol) | 30 | 1 |
| Charcoal Activated Liquid | 120ml | 1 |
| Diphenhydramine 25mg Caplets | 24 | 1 |
| Ear Relief (Alcohol Free) | 10ml | 1 |
| Guaitussin DM Cough Syrup | 120ml | 1 |
| Ibuprofen 200mg U/D Tablets | Each | 10 |
| Loperamide 2mg Caplets | 12 | 1 |
| Pseudoephedrine 30mg Tablets | 24 | 1 |
| Sting Relief Medicaine Swabs | 10 | 1 |
| NOT FOR USE IN HYPERBARIC CHAMBERS | | |
| Alcohol Preps | 10 | 10 |
| Insect Repellent Pump Spray | 2oz | 1 |
| Oxymetozaline Nasal Spray | 15 ml | 1 |
| Sunscreen Lotion (SPF 30) | 120ml | 1 |

Disclaimer: This First Aid Kit is compliant with ADCI CS 6.1, ANSI#Z308.1-2009, OSHA#29CFR1910, USCG#46CFR160 & 197, AND USACE EM385-1-1 requirements for both inshore and off shore commercial divers and is Hyperbaric / Decompression Chamber compatible with the exception of the listed items in the NOT FOR USE IN HYPERBARIC CHAMBERS section.

## 5.5 DESIGNATED DIVING SUPERVISOR

1. A qualified person shall be designated in charge of each diving operation. The responsibilities of such designated persons should include job planning, coordination, record keeping and proper response to any job-related emergency, as well as knowledge of the appropriate governmental regulatory agency regulation. **(Reference Section 3: Diving Personnel Responsibilities, Qualifications and Certifications.)**

**All ADCI general member company supervisors must possess a current ADCI supervisor certification card reflecting the level of diving being conducted.[1]**

## 5.6 STANDBY DIVER REQUIREMENT

At least one member of every dive team shall be designated the standby diver and should be suitably prepared to enter the water when directed by the diving supervisor.

Prior to commencement of the operation, the standby diver's equipment shall be fully verified as functioning correctly and thereafter maintained in that condition until completion of the dive. Should the standby diver be required to enter the water, a surface check shall be completed to ensure proper breathing gas supply, bailout function and effective communications before the diver leaves the surface. The standby diver shall utilize the same mode and level of equipment as the primary diver.

If there are two or more divers in the water, there is a still a requirement for a topside diver and tender. All divers must be actively hand-tended by a member of the dive team.

## 5.7 PLANNING AND ASSESSMENT

<u>The planning of a diving or underwater operation shall include a dive operations plan.</u>

During the planning and assessment phases of a diving or underwater operation, before diving operations commence, a plan must be developed to ensure the safe and efficient performance of the work. In either case, the dive operations plan is a critical element of any diving or underwater project.

In general, the operations plan will address such issues as the details relative to the goals and methods for the project, operational sequence, operational safety, crew and equipment requirements, emergency procedures, communications, and regulatory requirements. This list is not finite, and the items to be addressed in the dive operations plan will be uniquely dictated by the specifics of each particular project.

A dive operations plan differs from the Job Hazard Analysis (JHA) in that JHA is focused specifically on project safety only, whereas the dive operations plan is designed to ensure the work is well-understood and properly planned, manned and equipped.

### 5.7.1 JOB/PROJECT SAFETY

- Dive operations should be planned in accordance with regulatory authorities and ADCI consensus standards.
- An ADCI certified diving supervisor shall be in charge of the diving operation.
- All diving personnel shall be ADCI certified for the task they are assigned.
- An emergency response plan shall be available, posted and reviewed by all personnel.
- A pre-dive safety meeting shall be conducted.
- The job and all tasks shall be defined, reviewed and understood by the dive team and vessel personnel.
- The supervisor will perform a job-specific JHA.

### 5.7.2 DIVING AND SUPPORT PERSONNEL

- Ensure all divers are trained and experienced for the task they are to perform.
- Verify that all divers are physically and mentally fit to dive.
- Ensure that all personnel on the job have direct communication with all parties directly involved in the dive operation.

### 5.7.3 EQUIPMENT

- Ensure that dive gear and support equipment has been inspected/checked and ready for dive operations. (See basic example of pre-dive checklist in Section 10: ADCI Compliance Audit Procedures.)
- Ensure all emergency and support equipment has been inspected/checked and is fully functional.
- Ensure all needed methods of communication are available and functioning.

- Ensure all first aid/CPR (resuscitator) equipment and kits, as well as backboard, are well-supplied and available.
- Ensure that all dive flags/shapes/signals are prominently displayed during dive operations.

## 5.8 JOB HAZARD ANALYSIS (JHA)

(See Section 11: Reference Materials for a sample JHA form.)

**Before any underwater task is begun, a job safety analysis (JHA) shall be performed.**

The purpose of the JHA is to provide a written document identifying hazards associated with each step of a job and develop solutions that will either reduce, eliminate or guard against hazards. On the JHA, sentences should be short and simple. The ADCI sample JHA form in the Section 11: Reference Materials can be copied and used as is or modified to suit individual company needs.

1. **Sequence of Basic Job Steps**

   Break the job into observable steps. Do not be too general or overly detailed.

   - If the job is complex, break it into several tasks and prepare a JHA for each task.
   - Begin with an active verb, e.g., disconnect, check, invert, assemble, isolate, start, stop, etc.
   - Number each step.

2. **Potential Hazards**
   - Identify possible hazards associated with each step and list that hazard opposite the job step.
   - Consider potential accident causes (strain, sprain, slip, fall, cut, crush, etc.).
   - Consider environmental and health hazards (vapors, gasses, heat, noise, toxicity, etc.).

3. **Recommend Safe Procedures and Protection**
   - Develop solutions for each potential hazard and list the solution opposite the hazard.
   - Detail controls, e.g., ventilate, isolate, allow to cool, secure, guard, train, etc.
   - List personal protective equipment (PPE) required, e.g., gloves, eye protection, respirators, fall protection, etc.

4. **Assign Responsibility**
   - Assign a specific person the responsibility of implementing the safety procedures or protection required.

5. **Personnel Involved**
   - Identify the persons preparing, reviewing and approving the JHA.
   - Distribute the JHA to all personnel involved in the job or task and ensure that each person is familiar with the contents of the JHA.

6. **Revising the JHA**

The JHA should be reviewed and updated whenever new equipment, products or procedures are introduced into the work site. This is especially true if an accident has occurred on a task upon which a JHA has been performed.

## 5.9 TEAM BRIEFING

1. <u>Before commencing with any underwater operation, the dive team members shall be briefed on:</u>
   - The tasks to be undertaken.
   - Safety procedures for the diving mode.
   - Any unusual hazards or environmental conditions likely to affect the safety of the underwater operation.
   - Any modifications to operating procedures necessitated by the specific underwater operation.
2. Before each dive, the diver shall be instructed to report and record any physical conditions, problems or adverse physiological effects that may render the diver unfit to dive.

## 5.10 TERMINATION OF DIVE

1. <u>The working interval of a dive shall be terminated when:</u>
   - Directed by the dive supervisor and/or the person in charge.
   - The diver requests termination.
   - The diver fails to respond correctly to communications or signals from a dive team member.
   - Communications are lost and cannot be quickly re-established with the diver, the tender/diver and/or the diving supervisor.

- In liveboating operations, the person controlling the vessel requests termination.
- The diver begins to use the diver-carried reserve breathing gas or the dive-location reserve breathing gas.

## 5.11 POST-DIVE PROCEDURES

1. After the completion of each dive, the diver shall:
   - Be questioned as to his or her physical condition.
   - Be instructed to report any physical problems or adverse physiological effects, including symptoms of decompression sickness or gas embolism.
   - Be advised of the location of an operational decompression chamber.
   - Be alerted to the potential hazards of flying after diving.
   - Be alerted to the potential hazards of traveling to higher elevations from the dive site.
2. After the completion of any dive outside the no-decompression time/depth limits, the following are recommended:
   - Take reasonable steps to have the diver remain awake and in the vicinity of the decompression chamber for at least one hour.
   - Instruct such divers to remain within two hours travel time of the decompression chamber for an additional five hours.
   - Instruct such divers of the hazards of flying after diving.
3. On any dive that results in decompression sickness, proper medical authority should be consulted prior to the diver flying after treatment.

## 5.12 COMPANY RECORD OF DIVES (DIVE LOG) REQUIREMENTS

**All supervisors and divers are required to keep personal dive logs.** Each employer shall establish and maintain a record of each diver's hyperbaric exposure. This record shall contain the following:

- Name and address of the company.
- Location, time and date of diving operations.
- Names of the dive supervisor, diver and tender/diver.
- Depth of dive.
- Bottom time.
- Approximate water temperature and thermal protection used.
- Environmental conditions (approximate sea state, underwater visibility and underwater currents).
- Decompression tables and schedule used.
- Elapsed time since last pressure exposure if less than 24 hours or repetitive dive designation.
- Breathing mixture used and composition.
- Type of work performed.
- Type of diving equipment worn.
- Any unusual conditions.
- For each dive for whom decompression sickness is suspected or symptoms are evident, the following additional information shall be recorded and maintained:
  - Description of decompression sickness symptoms, including depth and time of onset.
  - Description and results of treatments.
- Diver's condition upon surfacing. Diver Signature:______________________________

## 5.13 DECOMPRESSION PROCEDURE ASSESSMENT

Each employer shall:

- Investigate and evaluate each incident of decompression sickness based on the recorded information, consideration of the past performance of the decompression table used, and individual susceptibility.
- Take appropriate corrective action to reduce the probability of recurrence of decompression sickness.
- Prepare a written evaluation of the decompression procedure assessment, including any corrective action taken.

## 5.14 MINIMUM REST HOUR POLICY

Except in an emergency, diving operations personnel may work no more than 18 continuous hours when that work includes loading equipment; traveling to the job site by air, land or sea; setting up the dive station; standing by to commence diving operations; participating in diving operations; or any combination of same. After 18 continuous hours of performance, such persons must be provided a minimum of eight consecutive hours away from the dive station and engaged in no alternate work activity.

Excluded from the above are any hours during the initial 18-hour period where diving operations personnel may have been afforded an opportunity for an uninterrupted period of sleep in excess of four hours. That opportunity may be considered to have been afforded during such times as during transport to the job site by land, sea or air.

When duty at the dive station does not include activities under paragraphs 1 and 2 above, diving operations personnel will not be permitted to work more than 16 hours in any 24-hour period or 60 hours in any 96-hour period, except in an emergency. Furthermore, such persons must be given at least eight consecutive hours off duty between work periods.

An emergency exists when a there is direct threat to the continued health and wellbeing of an individual or individuals or a significant loss of property may take place as the direct result of an unplanned event.

### 5.14.1 COVERAGE

This policy is intended to apply to all members of the operating dive team, including diving supervisors, divers, life-support technicians and tenders. Excluded from this policy are persons falling into the contractors' management category, such as those performing duties of a project manager, project superintendent, diving superintendent or other individuals whose activities are not required to take place at the actual dive station during a regularly scheduled shift/watch.

## 5.15 HAZARDS TO UNDERWATER OPERATIONS

1. Notice shall be given of the planned underwater operations, including the daily start and finish times, to those in the vicinity whose activities may interfere with or pose a hazard to personnel engaged in the operation. These activities include underwater demolition, movement of surface vessels, lifting of material directly over the underwater operations, etc.
2. Diving operations shall not take place wherever hazardous activities or conditions in the vicinity pose a safety hazard to the divers or impair the support personnel from safely carrying out their work tasks.
3. In no case shall the diver be required to dive against his or her will.

## 5.16 DIFFERENTIAL PRESSURE (DELTA P)

A significant number of fatalities in the diving industry involve a differential pressure (Delta P) situation. Delta P is a particularly insidious hazard for several reasons:

- Delta P is invisible to a diver and strikes suddenly, without warning.
- Once entrapped by Delta P, there is almost no way to escape.
- If the velocity profile of a hazard is such that at the periphery, the diver may approach without any perceptible increase in the water flow velocity. By the time the diver can feel the water velocity, it is already at a dangerous level.
- Even small forces may be compounded by factors such as the immobilization of limbs or the geometry of the structure surrounding the Delta P hazard.
- The application of as little as 77 pounds of force (35 kilograms/343 newtons) on the torso can impair respiration and disrupt blood flow. A diver's chest, back, or abdomen trapped against a 9-inch by 9-inch opening with a Delta P of only 1 psi (less than 2.5 feet water head) would experience 81 pounds of force.
- Currents of 1 knot (0.5m/s/1.64 fps) or more are very difficult for a diver to overcome, and can sweep a diver, or diver's umbilical, into a Delta P hazard. A 6-inch diameter opening with a Delta P of 10 feet of water can create current velocities exceeding 1 knot 16 inches or more from the opening, depending on geometry of the surrounding structure; 10-inch opening with the same Delta P can create hazardous currents over 2 feet from the opening.

### 5.16.1 TYPES OF DELTA P

1. When water levels between adjoining areas vary and are attempting to equalize.
2. When water is adjacent to a gaseous void at lower pressure than the water pressure.
3. When water is mechanically drawn through intakes or pumps.
4. When water is mechanically drawn towards propellers or other types of thrusters on ships.
5. Positive pressure being released from HP subsea wells or pipelines.

### 5.16.2 EXAMPLES OF DELTA P

- Clogged intake screen (type 1 from above).
- Outlet screen/trash rack on dams (type 1 from above).
- Hole in a water storage tank (type 1 from above).
- Open sluice gates (type 1 from above).
- Opening in a barrier between two areas (type 1 from above).
- Transfer pipes (type 1 from above).
- Water tower drain (type 1 from above).
- Diver installing a section of pipe with flange protectors over the ends without a vent (type 2 from above).
- An existing hole in an underwater pipeline (type 2 from above).
- Cutting into an underwater pipeline or other void with Delta P (type 2 from above).
- Pump house intake (type 3 from above).
- Air lifts or dredges (type 3 from above).
- Draw from thrusters on a ship (type 4 from above).

### 5.16.3 RECOMMENDATIONS

- Attend a pre-job meeting to understand where the hazards may be.
- Know the layout of the facility you are working in. (Review plans of facility or as-builts, if available.)
- Understand where the potential for Delta P may exist.
- Ensure high-quality, well-informed leadership, backed up by the provision of adequate information, instruction and training, for the dive teams and other relevant personnel.
- Make sure the diver and supervisor know how the piping and valve systems work together.
- Make your concerns regarding potential Delta P hazards clear to personnel of the company you are working for.
- Check and ask about any pumps, suctions, gates or valves.
- Physically verify that all gates or valves around the divers' work area are properly positioned and locked/tagged out as applicable.
- Perform any lockout/tagout procedures necessary to perform the job as safely as possible.
- Calculate the water forces in the potential Delta P areas.
- Check for flow using a flow meter if applicable.
- Brief the diver as to the location of any possible suction. Use of a simple illustration can be very beneficial.
- Be cautious when diving on a structure where damage is suspected.
- Where possible, establish an exclusion zone of such a size as to incorporate a suitable safety margin around a hazard.
- Keep the divers' umbilical taut to prevent the umbilical from getting caught in a Delta P situation.
- Limit the amount of umbilical given to the diver.
- Keep in communication with topside and make sure topside and any other divers in the water know exactly where you are at all times.
- Verify that all the divers' equipment is properly hooked up, and ensure that there are no loose articles that could get drawn in.
- On dynamic positioning (DP) vessels, the diver's umbilical should be at least 16 feet shorter than the distance to the closest hazard, such as propellers and thrusters. The standby diver's umbilical must be 10 feet shorter than the closest hazard.
- The standby divers' umbilical must be long enough to be able to reach the primary diver at all times.
- Install screens or guards over openings when possible.
- If cutting into a low pressure area, cut slats spaced apart instead of holes in order to allow water to keep flowing even if the diver is in front of part of that opening.
- Special attention should be given to air lifts and dredges in all depths, especially those greater than 33 feet.
- A remote pre-dive survey may need to be conducted prior to divers entering the water. This may be done using an ROV, drop camera, flow meter, etc. (see remote pre-dive survey methods below).
- Consider the condition of the structure. Failing parts of the structure can allow a <u>Delta P hazard.</u>

**Control measures should be implemented as possible in the following order of importance:**

1. Eliminate the hazard:

- Dive on the downstream side of the hazard.
- Equalize water levels or fill any voids
- Substitute divers by using remotely operated vehicles (ROV).

2. Use engineering controls to eliminate the hazard (engineering controls should distance the diver from or prevent the formation of a Delta P hazard):
   - Limit the length of the diver's umbilical or lifeline.
   - Construct guards/screens or close valves to minimize entrapment potential.
   - Separate the diver from the hazard by using more than one valve (redundancy) when possible.
3. Use of safe systems at work:
   - Use lockout/tagout procedures to isolate valves, pumps intakes and propulsion devices.
   - Evaluate the effectiveness of the control measures prior to the diver entering the water.
   - Divers and crew should be given training to recognize pressure hazards and risks. The pre-dive safety meeting should encompass the risks of Delta P hazards.
4. Personal protective equipment (PPE):
   - Use of surface-supplied air breathing apparatus incorporating an umbilical with appropriate strength member.
   - Full face mask or helmet that incorporates topside communications.

### 5.16.4 REMOTE PRE-DIVE SURVEY METHODS

The use of some kind of water movement detection device is recommended when a potential Delta P situation exists. Even if the indicator on a valve or gate indicates that it is in the closed position, the indicators may not be functioning properly. For example, in the case of a bent control stem, the effective length of the stem will shorten, resulting in the indicator showing that the valve is in the closed position even though the valve or gate may not be completely closed.

Historically, a weighted mop head or similar device (telltale) was often lowered in front of a potential Delta P hazard. If it was drawn towards the area, or sucked in, that would indicate a Delta P hazard. This method is still used today and can be an effective means of determining the presence of a Delta P hazard. However, technology has advanced with the use of digital readout flow meters, which can be lowered through the water column and will electronically display the flow rate (typically in ft/s). This can be converted to knots if desired (see formulas below).

### 5.16.5 FORMULAS

The following formulas can and should be used to calculate the potential forces and flows that the diver may encounter while diving near a potential Delta P hazard. These formulas can also be used to express the potential dangers of a Delta P hazard to the client.

**Force due to differential pressure calculation (U.S. standard)**

**F=D x density x Area**

Where: F = Pounds of force

D = Difference in water level (ft)

density = 62.4 pounds per cubic foot of fresh water

density = 64.1 pounds per cubic foot of sea water

A = $\pi r^2$ for a circle (r is radius in feet)

A = Length x height (in feet) for a rectangle or square

**Example: A hole that is 1-foot x 2 feet is located 10 feet below water on a sinking ship. How much force would be on an object placed over the hole?**

***F=(10')(64.1)(2ft²) = 1,282 lbs.***

**Force due to differential pressure calculation (metric)**

**F=D x density x Area**

Where: F = Kilograms of force (kgf)

D = Difference in water level (m)

density = 1025 kg ·$m^3$ for sea water

density = 1000 kg ·$m^3$ for fresh water

A = $\pi r^2$ for a circle (r is radius in meters)

A = Length x height (in meters) for a rectangle or square

**Calculation of water flow through an opening (U.S. standard)**

**Q=3600 x (A) x (√ D)**

Where: Q = Flow rate (gpm)

A = Area of opening ($ft^2$)

D = Depth of water above the opening (ft)

**Calculation of water flow through an opening (metric)**

**Q=4.43 x (A) x (√ D)**

Where: Q = Flow rate ($m^3$/s)

A = Area of opening ($m^2$)

D = Depth of water above the opening (m)

**Convert feet per second to knots = (fps) x 0.5925 = knots**

### 5.16.6 MISCELLANEOUS FACTS

- If the velocity profile of a hazard is such that at the periphery, the diver may approach without any perceptible increase in water flow velocity. By the time the diver can feel the water velocity, it is already at a dangerous level.
- Even small forces may be compounded by factors such as the immobilization of limbs.
- The application of as little as 77 pounds (35 kilograms) on the torso can impair respiration and disrupt blood flow.**5.17.7**

### 5.16.7 REFERENCES

Association of Diving Contractors International, Inc. "The Hazards of Working in Delta-P Work Environments," 2010 Video.

For order information, go to www. .adc-int.org/products.php

Fisher, A.S.; Gilber, M.J.; Anthony T.G. "Differential Pressure Hazards in Diving," Health and Safety Executive RR761, (2009): pp 107.

Tucker, Wayne C. "Diver's Handbook of Underwater Calculations." San Pedro: Best Publishing Company, 1980. Print.

## 5.17 TEMPORARY IMPAIRMENT OR CONDITION

**Divers shall not dive or be otherwise exposed to hyperbaric conditions for the duration of any known temporary impairment or condition if such is likely to adversely affect health or interfere materially with the person's ability to safely perform a specific diving task or safely be exposed to hyperbaric conditions. These include, but are not limited, to colds, alcoholic intoxication or its aftereffects, influence of drugs, pregnancy, respiratory or middle ear diseases, skin or external ear infections, excessive fatigue, or emotional distress. The diver should be consulted before such determination is made. In no case shall the diver be required to dive or be exposed to hyperbaric conditions against his or her will, except for treatment procedures.**

## 5.18 ENTERING AND LEAVING THE WATER

There shall be a safe means for entering or leaving the water from the diving platform, such as a ladder, stage or other appropriate device. If a ladder is used, this device shall extend a minimum of 3 feet below the water surface. Additionally, the means of entering and leaving the water shall be adequate to facilitate rescue of personnel. In any instance where the air gap from the location of the dive station and waterline is greater than 15 feet (5 meters), it is highly recommended that a stage or other appropriate device be the preferred means of entering or exiting the water.

## 5.19 REQUIRED DECOMPRESSION CHAMBER AVAILABILITY

1. For any dive in excess of 100 fsw, dives deeper than 60 fsw (18.29 msw) when liveboating or where dives require decompression, a dual-lock decompression chamber having a minimum capability of 6 ATA (equivalent to 165 fsw/50.3 msw) shall be available and ready for use at the dive site.
2. Prior to mobilization on jobs not normally requiring a decompression chamber, a job hazard analysis shall be performed to determine whether a decompression chamber will be required at the dive location. Those considerations may include, but not be limited to:

- Dive site location with respect to a known and identified location of a decompression chamber that will be available under emergency circumstances.
- Multi-day and/or repetitive diving operations.
- Potential for diver fouling or entrapment.

Other potential hazards or factors that may cause the diver to incur decompression obligations.

- Liveboating operations.
- Remote locations.

## 5.20 INSPECTION OF LIFE-SUPPORT SYSTEMS, EQUIPMENT AND TOOLS

1. Before diving or other underwater operations commence, personnel shall confirm that all operational systems, equipment and tools to be used are in working order, appropriate for the tasks and are in compliance with the information presented in **Section 6: Life-Support Equipment: Requirements, Maintenance and Testing.**
   - To ensure the highest standard of safety, checklists shall be used to confirm that the systems, equipment and tools are in safe working order.
2. Operational systems, equipment and tools used in underwater operations shall be inspected daily and monitored throughout the operations by designated persons.
3. Each person engaged as a diver in the diving operation shall inspect his or her personal diving equipment and confirm its operational readiness prior to each use. The diving supervisor or his or her designated alternate shall be likewise required to check the equipment of each diver before the diver enters the water.

## 5.21 THERMAL EXPOSURES TO DIVING PERSONNEL

### 5.21.1 PROCEDURES FOR DIVING IN COLD WATER AND COLD WEATHER

(Cold water is defined as water that is less than 40°F/4°C.)

#### 5.21.1.1 Diver

1. To help prevent hypothermia, the diver should wear appropriate thermal protection based upon the water temperature and expected bottom time.
2. In cold water (below 40°F/4°C), a dry suit or hot water suit should be worn to keep the diver properly protected.
3. Make sure the suit fits properly and that all the seals are in good condition.
4. Because severe chilling can result in impaired judgment, the tasks to be performed under water must be clearly identified, and the diver's condition should be continually monitored.
5. Keep hydrated at all times.
6. Exercise on a regular basis.
7. Do not exercise in cold water to try and stay warm. Exercise will cause the body temperature to fall more rapidly.
8. Bring the diver up if the diver is showing minor or severe symptoms of hypothermia. Minor symptoms include uncontrolled shivering, slurred speech, imbalance and/or poor judgment. Severe symptoms include loss of shivering, impaired mental status, irregular heartbeat and/or very shallow pulse or respiration (this is a medical emergency).
9. Upon exiting cold water:
   - If the diver is wearing a wet suit or hot water suit, immediately flush the suit with warm water. Doing so will have a comforting, heat-replacing effect.
   - Get the diver to a dry and relatively warm area as soon as possible.
   - The diver should remove any wet dress, dry off and don warm, protective clothing as soon as possible.
   - Hot, non-alcoholic beverages should be available to the diver.

### 5.21.1.2 TENDER AND TOPSIDE

1. Topside personnel should wear warm, proper protective clothing.
2. Plan extra time to perform tasks under cold conditions.

### 5.21.1.3 EQUIPMENT AND MAINTENANCE

1. The moisture in an air compressor and air lines must be dealt with to prevent freezing in the air system, which can cause catastrophic damage or failures.
2. The dive crew can also make use of high-pressure cylinders, which generally will contain less moisture than air produced by a low-pressure compressor.
3. Topside must continually empty the excess water out of the volume tank to help reduce the amount of moisture in the system.
4. Do not allow the diver's umbilical to rest for long periods of time on cold surfaces (barge decks, etc.). Fittings on the umbilical can transfer the temperature from the cold surface and cause the moisture in the diver's umbilical to freeze.
5. In water temperatures of 37° F (3° C) or less, first stage regulator on bailouts should be equipped with a proper cold water setup (environmental kit).
6. Extra precautions must be taken to make sure that the bailout cylinders are completely dry inside, that moisture-free air is used and that the regulator is thoroughly dried prior to use.
7. If using a hot water machine, careful attention must be exercised to monitor the output temperature of the hot water machine. In extreme cold-water environments, the hot water machine is classified as life-support equipment. Failure in the system can cause catastrophic results for the diver.
8. Failure of the hot water machine during decompression must be considered during the operation and dive plan.
9. Gasoline and diesel engines must be cold-weather modified to prevent engine freeze-up.
   - Use proper lubricants in the diver's air compressor.
   - Use appropriate cold-temperature lubricants in pre-packed bearings.
10. Bring extra batteries for equipment. Cold temperatures can shorten the life of a typical battery.
11. A hypothermia management kit should be considered.
12. Extreme caution must be exercised when refueling in dry, cold weather. Static electricity should be "drained off" by grounding the equipment or fuel container (away from vapor openings) with the hand. Static electricity can form in the layers of clothing worn by personnel and can cause a spontaneous discharge of electricity, which can ignite fuels.
13. When using a funnel, use funnels with copper screen to help filter out ice particles and foreign debris.

Precautions should be taken to protect divers and topside personnel from adverse thermal exposure and maintain proper thermal balance while engaged in operations.

## 5.21.2 PROCEDURES FOR DIVING IN HOT WATER

(Hot water is defined as water that is greater than 87° F/30.5°C.)

### 5.21.2.1 Diver

1. In many cases, hot water is the product of an industrial process and is often contaminated. As such, proper contamination protection equipment should be utilized by both the diver and topside personnel. While protecting personnel from possible contaminants in the water, such protective equipment can exacerbate the heat issues to the diver and topside personnel, so extreme caution must be taken when contamination protection measures are necessary.
2. To help prevent hyperthermia, the diver should wear appropriate thermal protection based upon the water temperature and expected bottom time. In hot water environments, a tube suit that circulates cool water through an undergarment beneath a diver's dry suit may be used. These were originally developed for foundry workers but have been modified for use by divers in hot water environments. Some ADCI member companies have found them to be effective in water temperatures up to 100°F depending upon the exposure time of the diver. Beyond that, some member companies have performed short dives in temperatures up to 120°F, although this is an extreme environment (i.e. a normal hot tub is generally around 100°F to 104°F). For this environment, some companies use special suits called shroud suits, which consist of an outer garment that goes over the diver's dry suit. A large supply of cold water is pumped into the shroud suit and exits in a controlled manner, keeping a cooler temperature envelope around the diver. Because this is such an extreme environment with many safety hazards, it is advised that divers be used as a last resort.
3. Care should be taken to ensure that water flow to and from the diver does not become obstructed due to line kinks or other impediments.

4. Heat absorption can occur rapidly through the diver's pate and so this area must be kept cool. Additionally, the diver's breathing gas will be heated due to the umbilical being in the water and all excess umbilical shall be kept out of the water. Additionally, in extreme cases, other methods may be needed to ensure that the diver's breathing gas is delivered as cool as possible.
5. Make certain the suit fits properly and all seals are in good condition.
6. Because overheating can result in impaired judgment, the tasks to be performed underwater must be clearly identified, and the diver's condition should be continually monitored.
7. Keep hydrated at all times.
8. Ensure that the diver is in good physical condition.
9. Bring the diver up if the diver is showing minor or severe symptoms of hyperthermia. Since a diver might have been in water that may not be considered hot, support personnel must not rely solely on classical signs and symptoms of heat stress for land exposure but be aware of commonly encountered signs and symptoms of hyperthermia in diving. Minor symptoms include profuse sweating, high breathing rate, inability to think clearly, fatigue, headaches or lightheadedness, muscle cramps, nausea and vomiting. Severe symptoms include the cessation of sweating, sudden rapid increase in pulse rate, the change in mental status, disorientation or confusion, exhaustion and potential seizures, loss of consciousness or shock (this is a medical emergency).
10. Upon exiting hot water:
    - If the diver is wearing a chiller suit or a cold water suit, immediately flush the suit with cool water and remove after the diver is sufficiently cooled. If a dry suit is worn and cannot be immediately removed due to contamination, cool the exterior of the dry suit with cool water.
    - Cool, non-alcoholic beverages should be available to the diver.

#### 5.21.2.2 Tender and Topside

1. Overheating is a risk when wearing protective clothing while operating in contaminated environments. Constant monitoring of topside personnel for heat related issues is necessary in such situations.
2. Ensure that cool, non-alcoholic drinks are available, as well as cool, damp rags for cooling purposes.
3. Ensure that access to climate controlled environments is readily available, if necessary.
4. Continue to monitor topside personnel conditions as you would a diver.
5. Plan extra time to perform tasks under hot conditions.

#### 5.21.2.3 Equipment and Maintenance

1. In humid environments, volume tanks and filters will build up moisture and will need to be continually drained.
2. The dive crew can make use of high-pressure cylinders, which generally will contain less moisture than air produced by a low-pressure compressor.
3. Keep the amount of the umbilical in the water to a minimum. Doing so will reduce the amount of hot water contacting the air and coolant hoses, resulting in lower temperature air and coolant for the diver.
4. If using a cold water machine, careful attention must be exercised to monitor the output temperature of the cold water machine. In extreme hot-water environments, the cold water machine is classified as life-support equipment. Failure in the system can cause catastrophic results for the diver.
5. Failure of the cold water machine during decompression must be considered during the operation and dive plan.
6. A hyperthermia management kit should be considered.

Precautions should be taken to protect divers and topside personnel from adverse thermal exposure and maintain proper thermal balance while engaged in operations.

## 5.22 DIVING OPERATIONS WARNING DISPLAY

**For areas that support marine traffic, an appropriate warning display shall be exhibited near the work site so that it has all-around visibility. This may include, but is not limited to, shapes, lights, flags or placards. <u>These signals should be given only when actual diving operations are being conducted.</u> When diving from surfaces other than vessels in areas capable of supporting marine traffic, a regid replica of the international code flag "A" at least one meter (3'-3.5') in height shall be displayed at the dive location in a manner which allows all around visibilty, and shall be illuminated during night operations. It is also recommended that the "Dive Down" flag (red flag with a white diagonal stripe commonly used by recreational SCUBA divers be used in conjuction with the "Alpha" flag).**

## 5.23 DIVER-WORN OR CARRIED EMERGENCY GAS SUPPLY

**A calculated 4 minute minimum of EGS is required for the deepest depth to be attained.**

1. A diver-worn or carried emergency gas supply must be provided for all diving operations, except where heavy gear (defined as diving equipment of the nature of the U.S. Navy MKV, or equivalent) is involved.
2. A diver-worn or carried emergency gas supply shall provide a physiologically appropriate mixture and a minimum four-minute capacity for the depths involved.
3. Diver-worn or carried emergency gas supply must provide a positive indication to the diver that his or her reserve has been actuated. Such an indication can be the requirement for the diver to open a valve, a visual signal or other appropriate method, such as a pre-dive bailout drill.

**Note: Consideration of the reserve breathing gas cylinder duration should be a part of pre-dive planning.**

4. The diver-worn or carried emergency gas supply shall be of sufficient duration for use until the diver can reach the surface (including any required in-water decompression) from the maximum depth of the dive; can reach another source of breathing media; or can be reached by the standby diver equipped with another source of breathing media. When a stage is used, where additional gas supplies are available, the diver-worn emergency gas supply does not need to be of sufficient amount and duration to take the diver through any required decompression.

The following information is provided to aid in selecting a reserve breathing cylinder size appropriate for the intended dive operation.

Gas consumption can be determined by the following calculation:

**EMERGENCY GAS SUPPLY DURATION FORMULA**
**DA = VA/CD**
**DA = Duration in Minutes**
**VA = Available Volume**
**CD = Consumption Rate at Depth**
**Consumption rate at depth = Volume minute X depth in bars or atmospheres**
**Gauge pressure minus (depth in pressure + regulator delivery pressur) = usable gas pressure**
***Refer to Bailout Calculations for Cylinders in Section 11**

NOTE: The available volume depends on the type (rated volume and rated pressure) and number of cylinders used, the measured gauge pressure and the recommended minimum cylinder pressure.

5. In all cases, the activation of the diver's reserve shall cause the dive to be aborted, unless primary gas can be immediately restored. The reason for activation of the diver's reserve must be ascertained and corrected prior to continued use of the involved equipment.

## 5.24 VOICE COMMUNICATIONS ON STATION

There shall be a properly functioning two-way audio-communication system between the diver and the normal station of the diving supervisor at the dive location.

During the conduct of underwater operations, topside communications must be established, and continuously maintained for the duration of the dive, between the supervisor, winch operator, person in charge, and other key personnel as determined necessary during the conduct of the job hazard analysis. Use of headphones should be considered when background noise has the capability of hampering communications to all key personnel as determined necessary during the conduct of the JHA.

## 5.25 DIVE PLATFORM POSITIONING

Vessels from which diving and other underwater operations are conducted shall afford a safe working platform. Safe operations from dynamically positioned vessels are covered in Section 8 of these standards.

## 5.26 PERSONAL PROTECTIVE EQUIPMENT

The appropriate ANSI (or standard used within a particular nation) approved personal protective equipment shall be worn when required. These items may include, but are not limited to:

- Protective head gear.
- Protective footwear.
- Protective eyewear.

- A personal flotation device to appropriate regulatory standard.
- Hearing protection.
- Safety harness with approved double-locking elastic lanyard.
- Respiratory equipment.

## 5.27 SAFETY PROCEDURE GUIDELINES

The following are minimum guidelines that may require modification for each diving or underwater operations mode to meet individual company needs.

### 5.27.1 SAFE PRACTICES/OPERATIONS MANUAL

1. Each employer shall develop and maintain a safe practices/operations manual as required by applicable government regulations and the ADCI and shall make this manual available at the dive location to each dive team member. This manual must provide for the safety and health of the divers. Associate Member Schools are required to have their own version of a Safe Practices & Operations Manual, specific to the safety of both the students and instructors. The manual shall be available at the dive location or at each dive station at the school. The safe practices/operations manual shall meet or exceed the requirements of the ADCI International Consensus Standards for Commercial Diving and Underwater Operations.
2. The ADCI International Consensus Standards for Commercial Diving and Underwater Operations may be used as a set of minimum guidelines to assist companies in developing their own specific safe practices/operations manual. Each employer is responsible for completing, modifying and/or complementing any of the procedures, checklists and standards in accordance with applicable governmental regulations and as dictated by specific policies and practices of the employer.
3. The safe practices/operations manual shall, at a minimum, contain the following information:
   a. A copy of applicable government regulations for the conduct of commercial diving or other underwater operations.
   b. For each diving mode engaged in:
      I. Safety procedures and checklists for commercial diving operations.
      II. Assignments and responsibilities of dive team members.
      III. Equipment procedures and checklists.
      IV. Emergency procedures for fire, equipment failure, adverse environmental conditions, medical injury and illness.
4. The ADCI strongly recommends that each safe practices/operations manual contain a definitive statement regarding the use of drugs or alcohol. Such language should include references to applicable governmental regulations regarding drug and alcohol use in the work place. Additionally, such a statement should reference the employer's ADCI-required drug and alcohol program (reference Section 5.3: Drug and Alcohol Screening).

### 5.27.2 EMERGENCY AID

1. Each contractor/school shall develop and maintain a list of the available sources of emergency aid, equipment and professional assistance with call signs, phone numbers or other means and instructions for establishing contact with them for locations where operations are conducted. The hours of operation of the nearest hyperbaric facility, along with its chamber capability, i.e. 6 ATA or 165'.
2. Each contractor/school shall make the contact list available at the company's principal place of business, at the field operations office and to those who may have a need for it to fulfill the company's emergency response plan.
3. The list shall include information necessary to obtain the following types of emergency aid as appropriate for the type of diving or underwater activity conducted:
   - Decompression chamber to accommodate U.S. Navy Treatment Table 6.
   - Hospital or medical treatment facility.
   - Air or ground transportation.
   - On-call physician that is knowledgeable of the type of diving operation conducted to treat for potential diving-related illnesses.
   - Coast Guard or other national Rescue Coordination Centers.
4. Two-way communications shall be available and accessible at any diving, hyperbaric or other underwater work site in order to engage emergency services as required.
   - Nearest decompression chamber (off-site).
   - Nearest hospital/medical treatment facility.
   - Air or ground emergency transportation.

- On-call physician.
- U.S. Coast Guard, other national Rescue Coordination Centers, or other responding authority.
- Emergency rescue source other than U.S. Coast Guard.
- Two-way communications available on site and where practical, tested to emergency response link.

### 5.27.3 FIRST AID

- First aid kit.
- First aid manual.
- Bag-type manual resuscitator.
- Full floatation backboard or Stokes litter, complete with head restraint and restraint straps.

### 5.27.4 PLANNING AND ASSESSMENT

- Written dive plan outling the steps and sequence of operations. Note: Commercial diver training programs should also have written dive plans, as a training aid, outlining the steps and sequences of the operation.
- Job hazard analysis.
- Site assessment.
- Evaluate environmental pollution containment and response readiness where applicable.
- Diving model/equipment system(s).
- Means of water entry and exit.
- Breathing gas supplies, including reserves (set up and tested).
- Thermal protection (all dive team members).
- Dive team assignments/briefing and fitness to dive.
- ROV team assignments/briefing and readiness to conduct operations.
- Inert gas status of dive team members (repetitive dive designations).
- Decompression and/or treatment procedures (including altitude).
- Communications procedures and methods for all personnel involved in the operation.
- Emergency procedures.
- Dive station setup.
- Any necessary modifications to the safe practices/operations manual.
- Report on the nature and planned times of the intended operation and the involvement of the vessel or facility's equipment and personnel to the person in charge.

### 5.27.5 HAZARDS TO DIVING OPERATIONS

- Surface vessel, vehicular traffic or aircraft operations.
- Overhead crane/gantry operations.
- Pedestrian traffic.
- Vessel and dive equipment weather limitations.

### 5.27.6 UNDERWATER HAZARDOUS CONDITIONS

- Umbilical fouling and/or entrapment.
- Differential pressures.
- Lockout/tagout.
- Contaminated or toxic liquid.
- Limited access/confined space/penetration.
- Use of explosives or seismic activities.
- Underwater sonar.
- Cathodic protection.
- Marine life.
- High currents/severe tidal conditions.
- Foreign waterborne materials, such as logs, ice flow, etc.

### 5.27.7 RECORD KEEPING

- Project description/accomplishment records completion.
- Diving and treatment records, accident reports.

## 5.28 LIFE-SUPPORT EQUIPMENT PROCEDURES CHECKLIST

The following are minimum guidelines that may require modification for each diving mode to meet individual company needs.

### 5.28.1 EQUIPMENT PREPARATION

1. Assemble, lay out and inspect all diving equipment and spares intended for the job including all accessory equipment and tools.
2. Check all helmets and masks and ensure that they are certified and properly functioning.

### 5.28.2 GENERAL EQUIPMENT

1. Check that all accessory equipment — tools, lights, special systems, spares, etc. — are on site and in working order.

### 5.28.3 PREPARING THE BREATHING GAS SUPPLIES

**The ADCI does not recommend the use of 100 percent $O_2$ as an in-water breathing media. However, should $O_2$ (in excess of 50 percent) be used for in-water breathing media, the equipment should be $O_2$ clean and designed for use with pure oxygen.**

1. Check that primary and suitable back-up breathing gas supplies are available and that breathing gasses comply with regulations for purity; are available in sufficient volumes; are properly mixed to accommodate the diving mode and profile; and that supply pressures are adequate for the intended operations and helmets/masks to be utilized.
   i. Ensure that the available breathing gas supply pressure is adequate for the intended depth and duration of the dive and that the supply pressure will accommodate the over bottom pressure requirements for the helmet or dive mask to be utilized as established by the manufacturers' instructions.
   ii. The over bottom supply pressure requirement for the intended helmet or mask to be utilized on the dive can be determined by reference to the manufacturer's specifications.
   iii. Minimum flow requirements for helmets/masks should be based on manufacturer's recommendations.

**Example: Air flow requirements can be calculated by:**

$$\textbf{FLOW} = \frac{D + 33}{33}(\textbf{ACFM})(n)$$

**ACFM** = Flow required based on manufacturer's recommendations

**n** = Number of divers

**D** = Depth in feet

- Standby diver must be included in the equation. Thus, if the dive will be performed by one individual, (n) will be 2.
- D equals the depth of the intended dive.
- ACFM equals the minimum air flow requirement; however, it may be higher as determined by the manufacturer's specifications for the intended helmet/mask.

2. Ensure that the breathing gas supplies are adequate to include decompression, recompression and necessary equipment throughout all phases of the planned operation.
3. Verify that all breathing gas supply systems have a suitable volume tank and filtration system installed in the air supply line between the supply source and diver's hose connection. A filtration system must be installed between the volume tank and dive manifold.
4. Verify that all supply hoses running to and from the compressor have proper leads, do not pass near high-heat areas such as steam lines, are free of kinks and bends and are not exposed on deck in such a way that they could be rolled over, damaged or severed by machinery or other means.
5. Verify that all high-pressure supply and interface hoses have safety lines and strain relief properly attached.
6. Compressors:

- Determine that sufficient fuel, coolant, lubricants and anti-freeze are available to service all components throughout the operation. All compressors should be fully fueled, lubricated and serviced.

- Verify that oil in the compressor is of an approved type. Ensure that compressor oil does not overflow the fill mark during servicing, as this is a source of potential contamination of the air supply. Any oil spillage must be cleaned up immediately.
- Check that the compressor's exhaust is vented away from the work area, and specifically that the air compressor intake is not in the path of exhaust gasses. Check that the compressor inlet is located in an area free of potential contamination.
- Check that compressors are not covered during operation.
- Check all filters, cleaners and oil separators for cleanliness.
- Bleed off all condensed moisture from filters and from the bottom of volume tanks.
- Check all manifold drain plugs.
- Check that all valves are properly aligned.
- Check that all belt-guards are properly in place on drive units.
- Check all pressure-release valves, check valves and automatic unloaders

### 5.28.4 ACTIVATING THE BREATHING GAS SUPPLIES

1. Compressors
   - Ensure that all warm-up procedures are followed correctly.
   - Check all petcocks, filler valves, filler caps, overflow points, bleed valves and drain plugs for leakage or malfunction of any kind.
   - Leak check all valves and connections.
   - Verify that there is a properly functioning pressure gauge on the air receiver and the compressor is meeting its delivery requirements.
2. Cylinders
   - Check all cylinders for proper pressure.
   - Verify availability and suitability of reserve cylinders.
   - Check all manifolding and valving for operation.
   - Activate and check delivery.

### 5.28.5 BREATHING GAS HOSES

1. Ensure all hoses have a clear lead and are protected from excessive heating or physical damage.
2. Briefly blow through hoses prior to connection.
3. Check breathing gas hoses and fittings for leaks and flow.
4. Ensure that breathing gas hoses (umbilicals) are properly marked to determine the distance the umbilical is paid out from the dive control station.
5. Ensure that breathing gas hoses (umbilicals) are suitable for the gasses to be used and have been maintained in proper conditions of cleanliness.

### 5.28.6 TESTING OF EQUIPMENT WITH BREATHING GAS SUPPLY ACTIVATED

1. Check all exhaust and non-return valves.
2. Hook up all breathing gas hoses to helmets, masks and chamber; make connection between back-up supply and primary supply manifold.
3. Ensure breathing gas mixture is suitable for depth and diving mode used.
4. Verify flow to helmets and masks.

### 5.28.7 DECOMPRESSION CHAMBER CHECKOUT (PRE-DIVE ONLY)

1. Check that the chamber is completely free and clear of all combustible materials.
2. Check primary and back-up air supply to chamber and all pressure gauges.
3. Check that the chamber is clean and free from contaminants. Check all chamber BIBS supplies. Verify that sufficient appropriate breathing media is available and that overboard dump systems (if fitted) are functional.
4. Verify the medical kit is available and in close proximity to the chamber.
5. Check all doors and seals.
6. Check that chambers meet code requirements with respect to periodic tests required by ASME/PVHO or equivalent.
7. Check that all valves are in the correct position.

8. Hook up and test all communications.

### 5.28.8 FINAL PREPARATIONS

1. Verify that all necessary records, logs and timesheets are on the diving station.
2. Check that appropriate decompression and treatment tables are readily at hand.

## 5.29 HAND-HELD POWER TOOLS

The following are minimum requirements for hand-held power tools. Prior to use of any hand-held power tools, a job safety analysis shall be performed.

### 5.29.1 ELECTRICAL HAZARDS

1. All hand-held electrical tools, including hand-held electrical equipment, shall be de-energized at the surface before being placed into or retrieved from the water.
2. All underwater AC (alternating current) electrical equipment cabled from topside shall be powered via a ground fault circuit interrupter (GFCI) between the topside power source and the tool.
3. GFCIs are used to assist in protecting divers against electrocution when using AC power underwater. GFCIs used shall meet all applicable regulatory requirements.
4. Have plug and receptacles compatible with cabling and dedicated ground cable.

### 5.29.2 SWITCHES AND CONTROLS

All hand-held power tools (e.g., hydraulic and pneumatic tools, water blaster guns) shall have a constant pressure switch or control (except for underwater welding and burning equipment).

- Hand-held power tools shall not be supplied with power from the dive location until requested by the diver.

## 5.30 WELDING AND BURNING

The following are minimum requirements for underwater welding and burning.

**CAUTION: Underwater welding and burning should be performed only by qualified personnel with prior training in these operations and should only be performed while utilizing surface supplied diving equipment with communication to the diver.**

As a minimum, the following shall be taken into consideration:

- Diver dress to ensure protection from shock.
- Proper equipment and setup (DC power, polarity, etc.).
  - Addressing the potential for existing explosive gasses and the creation of explosive gasses through the burning and welding process; also ensuring proper venting.
  - Ensuring that any members or compartments that can contain combustible gasses are either flooded or pressurized with an inert gas (nitrogen, carbon dioxide, argon, etc.) prior to cutting into them.

**Underwater welding and burning creates hydrogen/oxygen mixtures that are HIGHLY explosive. Ensure that all closed compartments, structures or pipelines subjected to the heat of underwater burning or welding are flooded or purged with water and vented. Ensure that gasses cannot be trapped by providing a vent location at the highest point. If unsure whether a compartment or pipe is fully flooded, vent holes shall be cold cut initially. Cold cutting: A technique that does not generate sufficient heat that could cause the ignition of flammable gasses or hydrocarbons.**

### 5.30.1 GENERAL REQUIREMENTS

- The diver shall wear adequate protective clothing (generally a rubber wetsuit or dry suit in good condition), including insulated gloves, while engaged in underwater welding or burning operations. Additionally, a diving helmet should be worn to keep the diver's head dry, to prevent the possibility of shock.
- While only partially immersed in the water, the diver is at risk of severe electrical shock when burning or welding. From the standpoint of electrical shock danger, the splash zone is the most hazardous location for divers while burning or welding. When working in the splash zone, divers must always wear a full wet or dry suit and insulating rubber gloves, in good condition, to insulate their bodies and hands.
- The diver shall use an appropriate welding shade to protect his or her vision when working in water with visibility.

- The diver shall be careful not to get between the ground and the work.
- The ADCI does not recommend burning or welding while using the scuba mode.

**While in the saturation diving mode, no gasses created during the venting/burning/welding process can be allowed to enter the diving bell. Close attention should be paid to current and tide shifts.**

### 5.30.2 EQUIPMENT AND SETUP REQUIREMENTS

Use only a DC power source for underwater burning or welding. There is extreme danger with the use of AC current in the water.

The welding power source should be checked out by knowledgeable personnel before use.

Select your machine by the amperage required at the torch head to burn the steel with the rod to be used. A high-end machine will burn on the low end; a low-end machine will not burn on the high end. On extended or critical burning jobs, a backup welding machine should be considered.

- All underwater burning or welding operations shall be conducted utilizing straight polarity.
- This can be remembered by the acronym P.I.G. (positive is ground). This will help prevent electrolysis to the torch or electrode holder. Welding machines that can be switched to supplyAC power are not recommended.

**Welding machine polarity could have been internally changed and differ from the external markings on the machine (e.g., indicated positive on the machine could actually be negative and vice versa).**

**To confirm straight polarity, insert the ground and the rod tip approximately 2 inches apart into a bucket of salt water. Energize the rod by closing the safety disconnect switch. A stream of bubbles should travel from the rod tip toward the ground clamp. If not, reverse the polarity and test again.**

- The ground shall be connected from the welding machine directly to the work. (In-water ground is not recommended.)
- A positive current safety disconnect switch (e.g., knife switch) shall be a part of the electrical circuit and shall be located at the dive control station in such a manner that it cannot be accidentally knocked or vibrated closed. It shall be capable of being immediately operated by the person in communication with the diver. The switch shall be rated for the maximum amperage utilized and shall remain open except during actual welding or burning. Due to the potential for arcing, the disconnect switch shall not be placed in a location that has the potential for oxygen or combustible gas buildup.
- Welding cables, electrode holders, underwater torches, and connections shall be properly insulated and capable of carrying the maximum amperage required by the work. Poorly insulated cables lying on a steel deck could allow for a current shunt around the safety disconnect switch. Electrode holders and torches shall be designed for underwater work.
- Ensure that all equipment is in good condition and that all manufacturers' recommendations are followed for the particular equipment being utilized. The underwater torch should have a good collet and washer, and it should be ensured that there is no oxygen leakage. All components of the system that may come into contact with oxygen shall be kept free of any grease or oil.
- In torches utilizing spark arrestors, ensure that the spark arrestor is in place.

### 5.30.3 SAFETY RECOMMENDATIONS

**Prior to the command to "MAKE IT HOT," the diver should squeeze the trigger to vent any possible build-up of hydrogen gas.**

- The diver should say "MAKE IT HOT" top side and then should say "MAKING IT HOT" and close the knife switch. When the diver completes a rod or burn, he or she should say "MAKE IT COLD" top side, then open the switch and say "IT'S COLD."
- Always keep tight control of the knife switch; never allow it to be closed when the diver is not burning, since this could cause injury to the diver or damage to the work site. Never mount the switch in a way that it could fall closed.
- Special consideration, planning and hazard identification should be considered for any habitat operations, including, but not limited to, habitat living parameters, atmospheric contaminant monitoring and ingress/egress of the habitat.
- Gasses from the burning/welding operation will collect in enclosed spaces as well as within shaped structural members such as under H-beams. ALWAYS ensure that adequate flooding/purging/venting has been accomplished prior to burning/welding. When in doubt, use cold cutting techniques to create vents.
- Trapped combustible gasses, such as methane from decaying organic material, may exist in submerged compartments in a barge or ship hull. Trapped gasses may also be present within a pipeline.
- When burning, if possible, start at the highest point and work downward to allow for gas venting. When burning large sections where entrapment from falling steel is a potential hazard, ensure that the section being cut is well-secured from topside, and cut the most difficult section first. The diver's body and umbilical should be outside of any potential danger zone when finishing the cut. Extreme care should be exercised when burning anything with tension upon it (cable, etc.), as it may spring back with tremendous force.

**The diver must be aware of his or her location, as well as his or her umbilical, at all times when burning, in order to avoid the potential for entrapment or injury from falling steel or molten slag.**

- Ensure that the disconnect switch (knife/contactor switch) is open when changing rods or laying down the electrode holder or torch.
- Ensure the disconnect switch (knife/contactor switch) is open prior to raising or lowering the torch/electrode holder or ground.

## 5.31 EXPLOSIVES

The following are minimum requirements for employing explosives. Prior to the use of explosives, a Job Safety Analysis shall be performed.

### 5.31.1 GENERAL

Employers must transport, store and use explosives in compliance with 29 CFR 1910.109, 29 CFR 1926.912 and the requirements of this section. Other state and local regulations may apply.

### 5.31.2 TRANSPORT AND STORAGE

Single-component explosives shall be transported and stored in magazine boxes. Blasting caps will not be stored with explosives.

### 5.31.3 CIRCUIT TESTS

Electrical continuity of explosive circuits shall not be tested with divers in the water.

### 5.31.4 AREA CLEARANCE

Divers shall be out of the water before explosives are detonated.

### 5.31.5 DETONATION DEVICES

All detonation devices shall be maintained under the custody of the diving supervisor when divers are in the water or when personnel on the surface are in the vicinity of explosives.

### 5.31.6 UNEXPLODED ORDINANCE

Unexploded ordinance, (or UXOs/UXBs, sometimes acronymized as UO) are explosive weapons (bombs, bullets, shells, grenades, land mines, naval mines, etc.) that did not explode when they were employed and still pose a risk of detonation, potentially many decades after they were used or discarded. If they are encountered, they should not be disturbed by untrained personnel, and appropriate authorities should be notified. The location of the unexploded ordinance should be noted.

## 5.32 UNDERWATER LIFT BAG OPERATIONS GUIDELINES

### 5.32.1 PURPOSE

- The purpose of this section is to identify potential hazards and recommend safety precautions when working with underwater lift bags.
- This recommended procedure is applicable for all sectors of the commercial diving community, both inland and offshore.

### 5.32.2 PRECAUTIONS

- When performing tasks underwater, divers are often required to move or lift objects using the assistance of underwater lift bags.
- Using underwater lift bags can pose a threat of uncontrolled ascent to the diver or object.
- Extra precautions should be taken through the performance of pre-dive hazard assessments.
- The dive supervisor should discuss each phase of the lifting operation in advance with all personnel involved, required equipment, rigging and the divers who will be carrying out the work
- Develop or establish an approved lifting plan prior to initiating any lift bag operations.
- Proper education and training (Boyles' Law/ Archimedes' Principle/ hydrostatic pressure/absolute pressure; see ADCI Physics and formulas in section 11)

<u>No standard can cover all potentialities that might be encountered. JHAs, common sense and extra attention by the entire dive team are considered essential components for approaching operations of this nature. JHAs should be updated as work progresses to reflect the current conditions.</u>

**Note: Underwater lift bags are not like other forms of lifting devices. The lifting action is produced by the displacement of water when the bags are filled with air. A diver must be aware of the position of his or her umbilical at all times to avoid fouling. Hose management is essential to prevent entanglement with the underwater air lift bag rigging or the object to be lifted. The use of enclosed lift bags or lift bags with multiple attachment points requires additional planning, and the user should refer to the manufacturer's suggested guidelines for proper use and operation.**

### 5.32.3 DEFINITIONS

**Anchor point:** (Also referred to as dead man anchor.) A point where the anchor line is attached to the underwater lift bag to restrain the load. Anchor points must have a mass in excess of the maximum lift capacity of the underwater lift bag.

**Dead Man Anchor (DMA):** Dead man anchor or independent anchor point which, after assessment, is a suitable fixed point from which to restrain the load. When selectinga DMA it is the inwater weight of the DMA combined with the inwater weight of the load that should be used.

**Diver operated filling method:** A filling method in which the diver using an air source such as his pneumofathometer or a dedicated air fill line controls the amount of air being placed into the lift bag at the lift bag itself.

**Dynamic Lift:** A lift bag is used to lift the load directly, typically for the movement of loads between locations. The lift bag and the load tend to be close to neutrally buoyant with a system of restraints in place.

**Dump line:** Line attached to the dump valve inside of the lift bag. It should be distinguishable from any other line. The dump line controls deflation of the lift bag by the diver. (Some lift bags are also outfitted with an extra length line, which can allow the diver to operate the dump valve from a safe distance.)

**Dump line anchor:** A weight attached to the dump line with enough mass to activate the dump valve during unplanned ascent.

**Dump valve:** Valve located inside of the lift bag for deflation of the lift bag, which is controlled by the diver through the use of the dump line.

**Enclosed Lift Bag:** Enclosed lift bags are fully enclosed bags equppied with an overpressure valve to prevent internal pressure from exceeding ambient pressure by more than a set amount. They are available in several configurations, including horizontal cylinder, vertical cylinder, enclosed parachute, and pillow.

**Inversion line/upset line:** Line attached to an appropriate anchor point, and to the top of the lift bag, to ensure that the bag inverts and deflates the air in the event of any failure of the lift bag's rigging.

**Main lifting lines:** This is the standard rigging that is attached to the lift bag, generally in either a two- or four-strap configuration. These lines are normally shackled to the object to be lifted.

**Parachute Lift Bag:** Parachte lift bags are open at the bottom. When fully any extra or expanding air will spill out and be released. The shape of a parachute lift bag should distribute the volume in a vertical rather than a horizontal direction so tht the open end of the bag always remains underwater.

**Remote inflation method:** A filling method in which the diver attaches the lift bag to the load and an independent inflation line from the surface. The diver is then allowed to back away from the lift into a safe position. Filling of the lift bags is conrolled from surface.

**Rigging:** All additional rigging attached to the lift bag to include shackles, straps webbing, cable, chains, etc. needs to be certified and load rated to meet at a minimum the lifting capacity of the individual bag being used.

**Static Lift:** A lift bag is secured by hold back rigging and used as a single lift point, the lift bag has very positive bouyancy, but it is directly restrained to anchor points, therefore the lift bag is fixed, and the load is free to move verically with the use of a suitably approved lifting device.

### 5.32.4 RESPONSIBILITY

The dive supervisor supervisor is responsible for the welfare and safety of the dive team. However, the diver is responsible for ensuring that he or she is familiar with the principles of underwater lift bag operations that he or she is performing. The diver is responsible for performing tasks utilizing underwater lift bags in a safe and responsible manner.

Dive supervisor is responsible for establishing a lift plan to include equipment requirements, inflation method, proper tending techniques, umbilical management, and potential hazards of the lift

Diver is responsible for understanding and proper execution of the established lift plan.

Dive supervisor and diver are responsible for using the required lift bag and associated hardware according to the manufacturer's recommendations at all times.

### 5.32.5 POTENTIAL HAZARDS ASSOCIATED WITH UNDERWATER LIFT BAG OPERATIONS

1. Over-inflation of the lift bag.
2. Accidental deflation of the lift bag.
3. Failure of the rigging or lift bag straps.
4. Failure of the lift bag fabric.
5. Utilization of a lift bag not rated for the load.
6. Obstructions in the path of the lift (water-column or surface).
7. Possible disruption of DP system during deflation of lift bags.
8. Possible entrance of deflated air into the diving bell.
9. Unplanned free ascent.
10. Diver fouling on lift bag or rigging during unplanned ascent.
11. Failure of attachment point.
12. Improper rigging hardware or rigging location.
13. Uncertified or unrated / under-rated rigging.
14. Incorrect lift bag type used for lifting operations.
15. Sudden or unplanned seabed suction release.
16. Lack of / incomplete inspectin of the lift bag and rigging used.

### 5.32.6 RECOMMENDED WAYS TO MITIGATE POTENTIAL HAZARDS ASSOCIATED WITH UNDERWATER LIFT BAG OPERATIONS

1. Situational awareness on the part of the diver and topside personnel.
2. Proper education and training (Boyles' Law/Archimedes' Principle/hydrostatic pressure/absolute pressure; see ADCI Physics and formulas in Section 11).
3. Ensure that an anchor/restraining line is present, when applicable, with sufficient strength to remain attached to the load and dead man anchor.
4. Ensure that dump lines are distinguishable from all other lines.
5. Ensure that diver's personal equipment and all other tools are not in a position to get fouled with the dump line.
6. Proper maintenance, inspection and testing of lift bag and its rigging. It is recommended that a log for the inspection and maintenance of each underwater lift bag accompany the lift bag whereever it is operationally deployed.
7. Attachment of an inversion line to the top of the lift bag (the inversion line should be secured to an anchor point).
8. Proper education and training, combined with visible markings to indicate the ratings of the lift bag and the units of measurement used to express that rating (lbs./kg). It is important to utilize lift bags that have a lift capacity that is as close as possible to the weight of the object to prevent the potential for additional tilt on ascent.
9. A complete assessment and survey of the area must be performed prior to initiating lift (inflation of the lift bag).
10. On DSV/DPV: The volume of air escaping from the lift bag during the deflation phase may affect the vessel's DP system; prior notification to the bridge should be made before initiating deflation.
11. It is important that lift bags are not deflated in the area directly underneath the diving bell, as this could pose a hazard to personnel inside of the bell.
12. Ensure anchor points, when applicable, are heavier than the greatest potential lift of the lift bag(s).
13. Use of lift bags should be done in accordance with the manufacturer'e recommendations.
14. When enclosed lift bags are used care should be taken to ensure tht all provided attachment points are utilized.
15. Develop or establish an approved lifting plan prior to initiating any lifting operations. The lifting plan needs to establish the required lift bag size and type, rigging, rigging locations, load weight, environmental conditions etc.

### 5.32.7 OPERATIONAL CONSIDERATIONS WHEN USING UNDERWATER LIFT BAGS

1. Weather and environmental conditions

   Factors to consider include:

   a. Current.

   b. Seabed obstructions.

   c. Seabed conditions.

   d. Seabed suction.

2. Details of the object to be lifted and its position in the water column

   a. The composition (what the object is made of and its approximate center of gravity).

   b. Assessment of the object's exact position and its stability.

   c. Determination the object's lifting points.

3. Perform all necessary calculations to determine the object's weight, taking into consideration the object's submerged weight, stability and its approximate center of gravity.
4. When making your calculations, it is important to assess the best position, number of bags, lift capacity of bag, and type of bags required to avoid damage to the object (bending or buckling). Determination of the inflation sequence to minimize the amount of partially filled bags at any one time when using multiple lift bags, is important to establish a safe and damage-free lift.
5. When using multiple divers during lifting operations visibility in the area of the divers work should be considered.
6. When possible use remote inflation/deflation methods to allow divers to move to a safe location during the lift. If remote inflation/ deflation is not possible ensure divers and all equipment are clear prior to operation of the lift bags.
7. When possible use lift straps (rigging) long enough so that the bags surface at the desired elevation of your load to be lifted.
8. Using the enclosed (or open) bag(s) as a surface lifting device, and placing a come-along, or chainhoist between the bag(s) and the load, so that you can control the lift incrementally and completely with the hoist - thus just using the bags as surface floataion.
9. After carefully calculating the load to be lifted (net weight underwater). Install enough bags to lighten the load, then the lift can be made in a controlled manner, utilizing less ocerall surface lifting capacity.

**NOTE: Extreme caution must be used when inflating underwater lift bags. Do not use excess buoyancy to "break out" or "free" a load from the seabed. Remember: In shallower water, air entering the bag will experience a greater percentage of change in volume as it rises than at deeper depths. Underwater lift bags inflate more rapidly at more shallow depths.**

### 5.32.8 APPLICATION OF LIFT BAGS

**Archimedes' Principal:** The Archimedes' Principle states that any object wholly or partly submerged in liquid experiences an upward thrust equal to the weight of the liquid displaced. The buoyancy of an immersed body can therefore be calculated by subtracting the weight of the object from the weight of the displaced liquid.

If the weight of the object is less than the weight of the displaced liquid, then the body is said to be positively buoyant, and it will float. If the two weights are exactly equal the object is neutrally buoyant and if the weight of the object is greater than the weight of the displaced water the object is negatively buoyant and will sink.

**Hydrostatic Pressure** - Hydrostatic pressure is the result of the weight of water acting on a submerged object, and like atmospheric pressure it is equal in all directions at a specific depth. This pressure increases at a uniform rate of 0.1005 bar/m (0.445 psi/ft) in saltwater.

**Absolute Pressure** - The absolute pressure exerted on a submerged body is the sum of the atmospheric pressure and the hydrostatic pressure. Normal atmospheric pressure at sea level is accepted as being 1.013 bar (14.7psi).

**Boyle's Law** - Boyles' Law states that at a constant temperature, the volume of any gas will vary inversely with absolute pressure, whilst the density will vary directly with the pressure.

Although temperature and pressure are important factors in scientific work, they can be ignored for practical purposes. We need only be concerned with the matter of contraction and expansion as the depth alters.

The basic formula derived from Boyles' Law for practical use is:

V1 = P2*V2/P1

Where: V1 = Volume of bag at 1 atm. absoloute ($m^3$ or cubic feet)
V2 = Resultant volume ($m^3$ or cubic feet)
P1 = Starting pressure (bar or psi)
P2 = New pressure (bar or psi)

**AIR REQUIREMENTS FOR LIFT BAGS**

A useful rule of thumb is to remember that the 35 $ft^3$ of air is required to lift 1 ton (long) or 2,240 lbs.

Ex: 2240/64 = 35 $ft^3$

Using the 'rule of thumb' mentioned above, that it takes 35 ft3 of air to lift 1 ton, it follows that a 5-ton lifting bag would require:

35 * 5 = 175 $ft^3$ air (1 atm)

However, with a pressure relief valve fitted, which ensures that the internal pressure is maintained at 2 psi is 13.6% of 1 atmosphere:

(2/14.7) * 100 = 13.6%

Thus, for a 5-ton bag with a relief valve, the revised volume of air necessary is:

175 * 1.136 = 198.8 $ft^3$

a) Atmospheres absolute: 15.24 * 0.1007 + 1 = 2.53 atm
b) Air required for 5-ton bag: 35 x 5 = 175 $ft^3$
c) 2 psi over - pressure = 0.136 atm
d) Total air required to operate relief valves at one atmosphere absolute: 175 * 1.136 = 198.8 $ft^3$
e) Total air required at 50 ft: 175 * (2.53 + 0.136) = 466.55 $ft^3$
f) Compressor time to fill bag: 466.55 / 50 cfm = 9.33 min
g) Air flow loss in hose: 9.33 * 0.333 = 3.08 min
h) Total time to fill bag: 9.33 + 3.08 = 12.41 min

## PRACTICAL CONSIDERATIONS

Assume that there is a piece of wreckage at the depth of 100 ft in the sea, which is to be raised. The basic information required is necessary in order to answer the following four questions:

a) What is the net "in water" weight of the wreckage?
b) What is its displacement?
c) What number and volume of lifting bags is necessary?
d) What minimum volume of air will be necessary?

Assume that the estimated mass of the wreckage is 10 tons (long), and that the material is steel. Now convert the estimated mass into lbs:

10 * 2240 lbs = 22400

Also determine from the given table of Material Densities, the density of steel, measured in:

Density of steel: $485 \frac{lb}{ft^3}$

**NOTE:** Density of steel has a general range of 485 to 503. For this example, 485 has been used.

a) Gross Weight in lbs in air/ Density of Material = displacement in ft3

$$\frac{19444}{485} = 46.19\ ft^3$$

Displacement in ft3 * weight of 1 $ft^3$ seawater = buoyancy force (lbs)

$$46.19\ ft^3 * 64 \frac{lb}{ft^3} = 2956\ lbs$$

Therefore the "in water" weight = 22400 - 2956 = 19444

**NOTE:** This "in-water" weight is only estimated, since it is difficult to obtain an accurate measurement of weight of irregular objects underwater.

b) In water weight of items in lbs / weight of 1 ft3 seawater in lbs. = total displacement to achieve neutral buoyancy

$$\frac{19444}{64} = 303.81 \text{ ft}^3$$

c) Lift in tons = displacement (ft3)/volume to lift 1 ton in $ft^3$

$$\frac{303.81}{35} = 8.68 \text{ tons}$$

Therefore, to render the lift neutrally bouyant only, it would be necessary to apply 8.68 tons. To achieve positive buoyancy, 9 tons of lift would be a reasonable calculation, depending on the geometry of the lift. Of the 9 tons of lift at least 1 ton would be used as buoyancy control (see comments later).

**NOTE*:*** that 8.68 tons represents 96.45% of the 9 tons available, therefore 3.55% or 716.8 lbs would represent the positive buoyancy.
ie: 9.00 tons - 8.68 tons = 0.32 * 2240 lbs. = 716.8 lbs.

716.8 lbs divided by 64 lbs gives 11.2 $ft^3$ of air to give the positive buoyancy

d) (i) Absolute pressure in atmospheres and psi:

$$100\text{ft} * 0.445 \frac{lb}{ft^3} + 14.7 \text{ psi} = 59.2 \text{ psi or } 30.48\text{m} * 0.1005 \frac{bar}{m} + 1 \text{ atm} = 4.06 \text{ atm}$$

(ii) Total volume of air required to inflate lifting bags. representing 9 tons at 100 ft depth:

$$9 \text{ tons} * 35 \text{ ft}^3 * 4.06 \text{ atm} = 1278.9 \text{ ft}^3$$

Since a compressor would be required to supply this volume of air, assume a supply capacity of 75 $ft^3$ per minute (cfm), then it will take approximately 12 minutes to inflate, but allowing a 1/3 increase for flow loss in the hose, then the time takedn to inflate will be:

$$\frac{1278.9 \ ft^3}{75 \ cfm} = 17.05 \text{ min}$$

17.05 * 0.33 = 5.63 min

Total time = 17.05 min + 5.63 min =22.68 min

## AIR REQUIREMENT FOR LIFT BAGS

Using the "rule of thumb", already mentioned that it takes 35 $ft^3$ of air to lift one ton, it follows that a 5-ton lifting bag would require:

35 * 5 = 175 $ft^3$ air (1 atm)

However, with a pressure relief valve fitted, which ensures that the internal pressure is maintained at 2 psi above ambient, then more than 175 $ft^3$ will be required. Since 2 psi is 13.6% of 1 atmosphere:

(2/14.7) * 100 = 13.6%

Thus, for a 5 ton bag with a relief valve, the revised volume of air necessary is:

175 * 1.136 = 198.8 $ft^3$

Considering a more practical problem; what calculations are necessary to use the 5 ton totally enclosed air bag at a depth of 50 ft (15.24 m) in seawater with a compressor of 50 $ft^3$ per min available?

a) Atmospheres absolute: 15.24 * 0.1007 + 1 = 2.53 atm
b) Air required for 5-ton bag: 35 x 5 = 175 $ft^3$
c) 2 psi over - pressure = 0.136 atm
d) Total air required to operate relief valves at one atmosphere absolute: 175 * 1.136 = 198.8 $ft^3$
e) Total air required at 50 ft: 175 * (2.53 + 0.136) = 466.55 $ft^3$
f) Compressor time to fill bag: 466.55 / 50 cfm = 9.33 min
g) Air flow loss in hose: 9.33 * 0.333 = 3.08 min
h) Total time to fill bag: 9.33 + 3.08 = 12.41 min

**Example**

While the previous example was calculated in imperial units, it may be necessary to be familiar with the same sort of calculations based on metric units.

What is the weight of a block of concrete measuring 51 cm * 30 cm * 25.5 cm (20 in * 12 in * 10 in) in air? What will its weight be when it is submerged in saltwater?

**IN AIR**

*In Metric Units*

W= pV

P= 2323$\frac{bar}{m}$

V=0.51m*0.30m*0.255m = 0.039015 m3

Convert to meters -

V=0.51m*0.30m*0.255m = 0.039015 $m^3$

W = 2323 $\frac{kg}{m^3}$ * 0.039015 $m^3$ = 901.63 kg

*In Imperial Units*

W= pV

P= 145 $\frac{lb}{ft^3}$

V = 20 in * 12 in * 10 in

Convert to feet -

V = 1.67 ft * 1 ft * 0 .833 ft = 1.39 $ft^3$

W = 145 $\frac{lb}{ft^3}$ * 1.39 $ft^3$ = 201.55 lbs

**UNDERWATER**

*In Metric Units*

$W_{sub}$ = V * ($p_o$ - $p_w$)

V= 0.039015 $m^3$

$p_o$ = 2323$\frac{kg}{m^3}$

$p_w$ = 1026$\frac{kg}{m^3}$

$W_{sub}$ = 0.039015 * (2323 - 1026) = 50.60 kg

*In Imperial Units*

$W_{sub}$ = V * ($p_o$ - $p_w$)

V= 1.39 $ft^3$

$p_o$ = 145 $\frac{lb}{ft^3}$

$p_w$ = 64 $\frac{lb}{ft^3}$

$W_{sub}$ = 1.39 * (145 - 64) = 112.59 lbs

Having looked quite closely at the theoretical aspects of this subject, let us now consider the practical application, and the first consideration must be “How much positive buoyancy is required in a lift?”

One of the major problems associated with the buoyant recovery systems is controlling the ascent velocity once the actual lift has begun. This is particularly true of collapsible lifting bags for a number of reasons. If the load is less than the bag capacity, ascent will commence before the bag has reached its maximum displacement. As it ascends, the gas will expand within the airbag, increasing its net buoyancy which will increase its ascent velocity. It is then important to use a bag with a pressure relief valve. It is most important to select bags with lifting capacity equal to the load, with possibly a smaller bag or crane assistance to provide the positive buoyancy control required. In any event, the ascent rate should never exceed 2-3 feet per second (fps).

What might be the result of too fast an ascent rate?

Should a lifting bag rise at a rate faster than 10 fps, a phenomena known as velocity heat may develop on the top surface, in which the force due to the upward motion reacts against the top face, forming a pressure head, deforming the bag and causing it to become unstable. In an extreme situation this may cause the bag to dump air, lose buoyancy and thus let the load return to the bottom. The ascent rate is therefore vital to the successful outcome of any lifting project. Accurate estimation of acceleration and final ascent speed is more difficult than the previous calculations. Initial acceleration is given by the total lift force divided by the total payload mass. In this case, in addition to the payload itself, the mass included an unknown quantity of entrained or trapped water. The final ascent speed is determined by the total lift force; which is then determined by the shape and drag area of the lift bag and payload combination.

The form of the equation is:

Lift force = Mass x Acceleration + Pressure Drag +Friction Drag Lift force = M * A + (0.5 * p * V^2) * (Cp * A1 * Cf * A2)

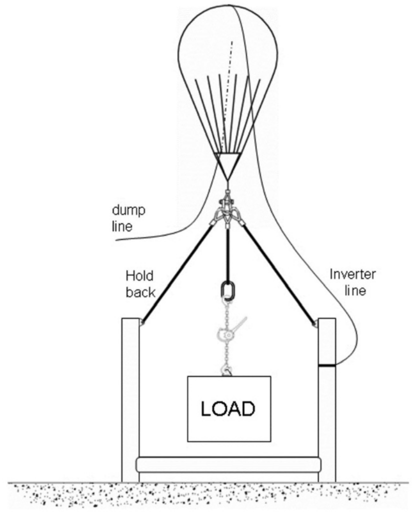
Where: M = Total mass (including added mass of water)
A = acceleration
P = water density
Cp = Pressure or Form drag coefficient
A1 = Horizontal area presented by payload and lift bags
Cf = Friction drag coefficient
A2 = Surface area in contact with flow

Accurate selection of bag capacity for precise acceleration and speed control is difficult because of the uncertainty in the values of M, Cp, Cf, as well as A1 and A2.

A rule of thumb, which has been found to give satisfactory results, and avoid excessive ascent speeds is to provide a lift force which is not more than 20% greater than the payload in-water weight.

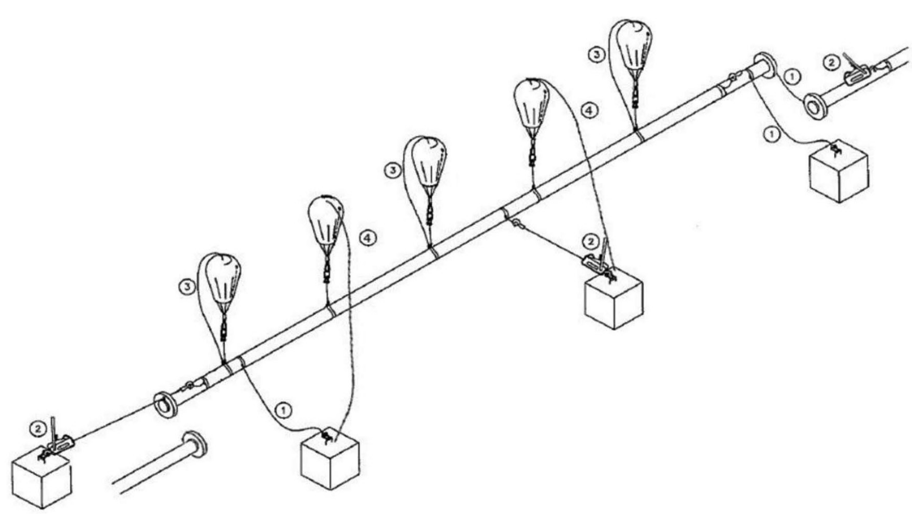
**EXAMPLE OF STATIC LIFT**

- Both the inverter line and hold-back line should be secured to a subsea structural member or a suitable DMA. Ensure hold-back line is shorter than the inverter line. The bag provides a fixed point from which the load can be either raised or lowered by mechanical means.
- In this example the lift bag rigging failure would result in the load and bag being grounded.




**EXAMPLE OF MULTIPLE AIRBAG LIFT**

- In complex lifts using multiple bags it is not necessary to secure each and every inverter line to existing structural members as they have the potential to become a trip hazard.
- A significant proportion of inverters should be affixed to strong points to decant sufficient buoyancy to ground the load. Holdbacks are required at either end.
- The hold-back line should be shorter than the inverter line. Positional/ alignment devices, such as lever hoists, are not suitable substitutes for holdbacks.
- In this example any rigging failure would result in the load and bag being grounded.

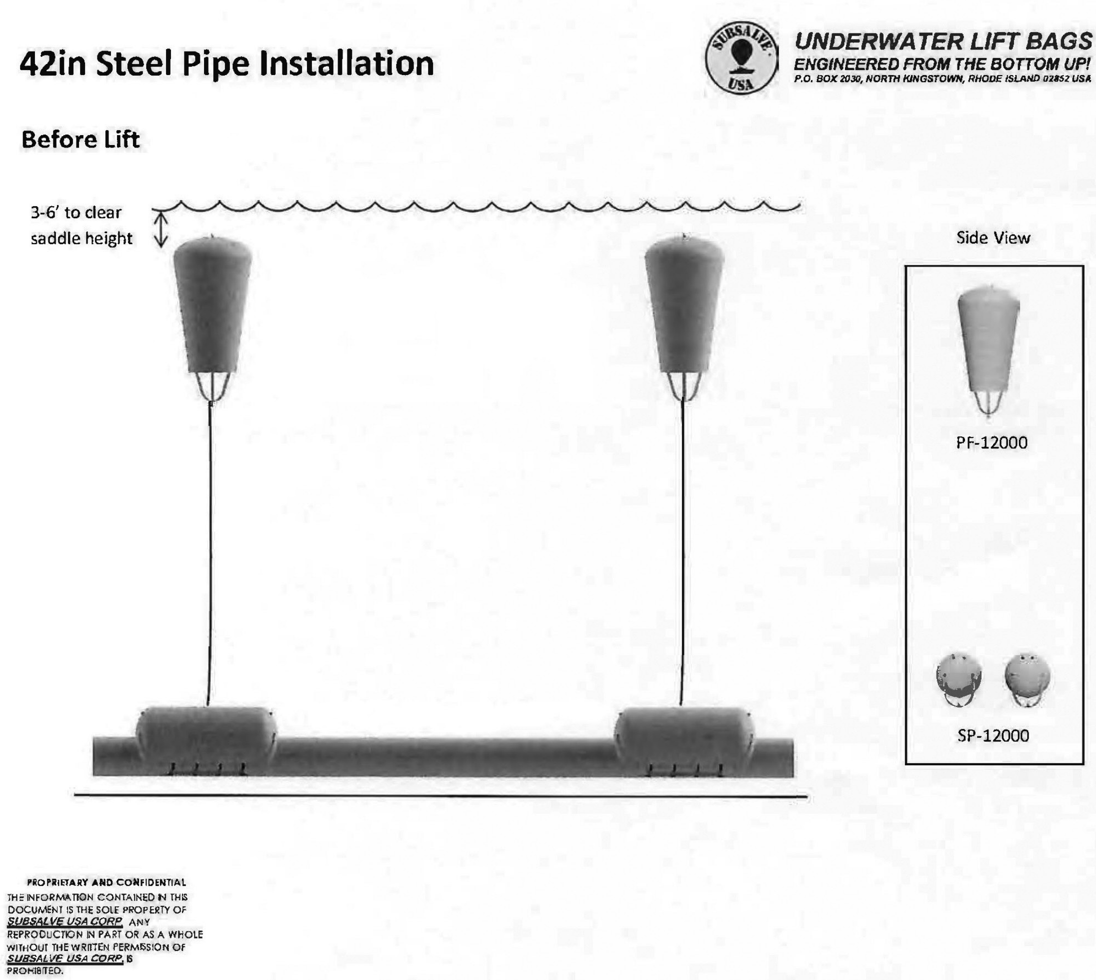


- Example of the lifting straps being long enough so that the bags reach the surface as the load reaches its desired height.
- Example of using the lift bags at the surface and hoisting the load with a chain-fall(S) or comealong(s).
- Example of lightening the load with lift bags, so that a lighter surface capacity lifting rig can perform the controlled lift. (Example: Heavy barge –lighten the load, raise with a smaller crane to the surface so it can be dewatered).

### 5.32.9 INSPECTION AND MAINTENANCE

- Prior to each use visually inspect all components of the lift bag.
- Prior to each use visual inspection of the webbing straps and stitching on the lift bag.
- Prior to each use inspect the dump valve at the top of the parachute bag to ensure that it is clean and operators freely.
- Ensure dump valve line is attached correctly and will operate the valve when pulled
- With parachute bags check the restraining line to ensure that it is attached to the specific inverter line attachment point of the bag so that the bag will invert should there be a failure of any part of the attached rigging or rigging point.
- With enclosed lift bags, the relief valve should be checked to ensure that it is free and clean.
- It is recommended to complete and maintain a logbook documenting use, damage, and repairs
- User should refer to the manufacturer's suggested guidelines for proper inspection and maintenance.
- Clean, lubricate, and store after each use according to manufacturer's recommendations

❖ **Example of load being controlled by the length of lifting straps used prior to lift.**



❖ **Example of load being controlled by the length of lifting straps used after lift is completed.**

## 42in Steel Pipe Installation

UNDERWATER LIFT BAGS
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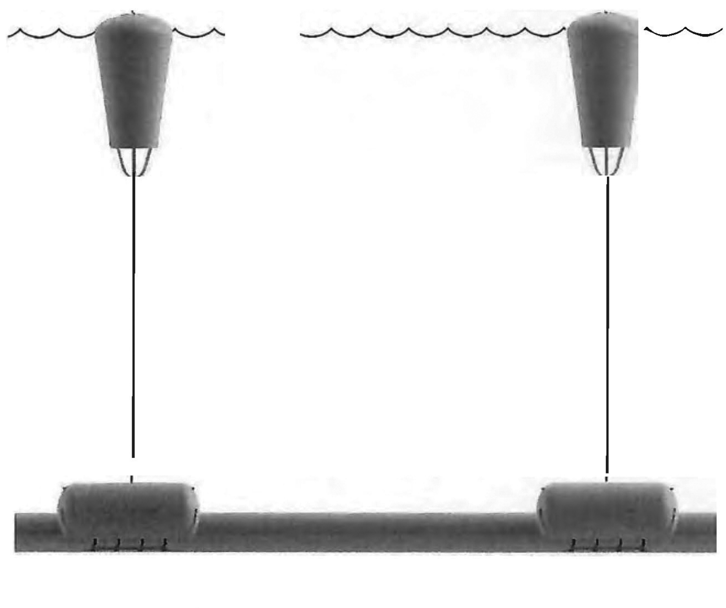
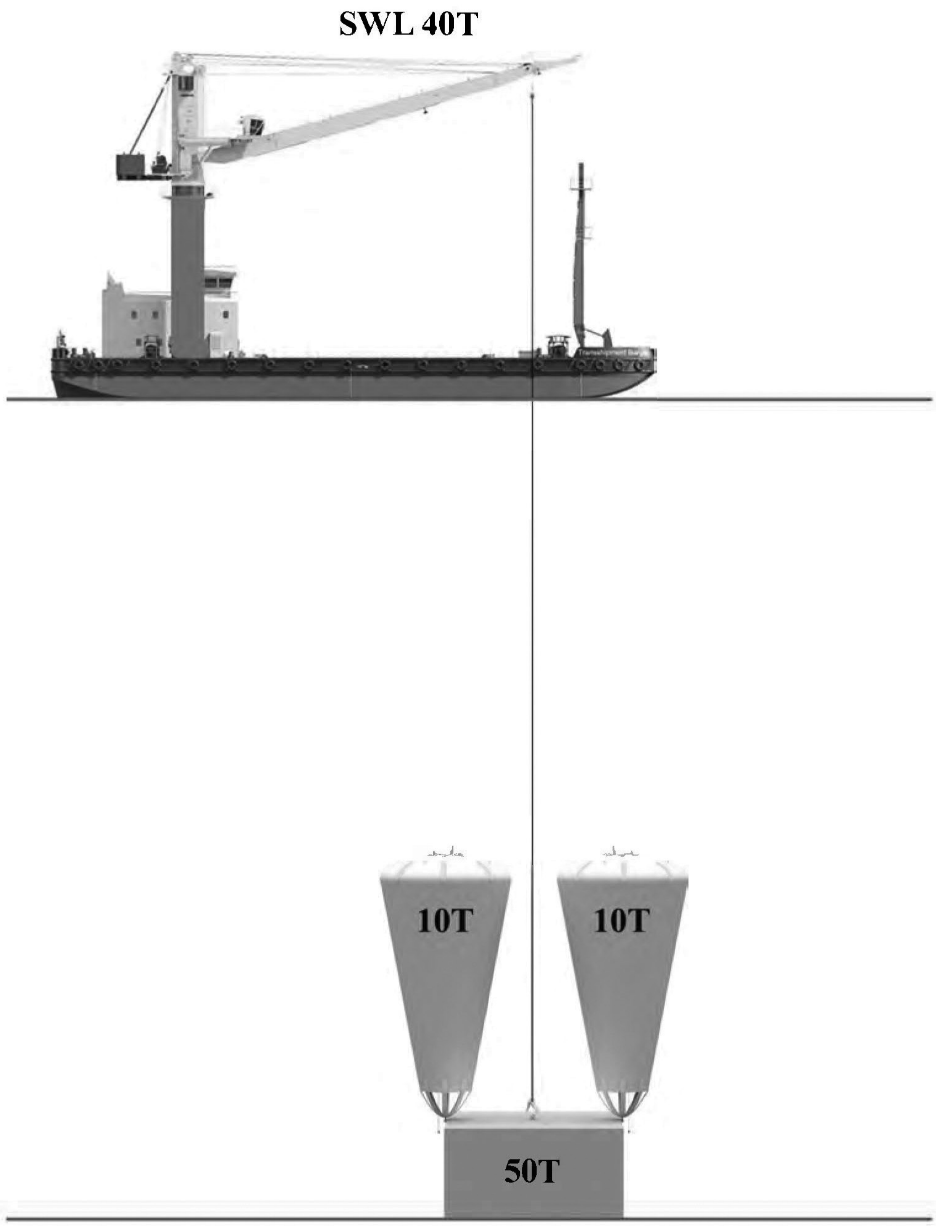
**After Lift**



❖ **Example of controlling the load by using a stationary bag at the surface and using a chain fall or come-a-long to raise the load incrementally.**

❖ **Example of using lift bags to lighten the load during a lift with a surface crane**



# AIR INFLATION CHART

| | Surface | 33’ | 66’ | 99’ | 132’ | 165’ | 198’ | 231’ | 264’ | 297’ | 330’ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ambient Press** | 14.7 | 29.4 | 44.1 | 58.8 | 73.5 | 88.2 | 102.9 | 117.6 | 132.3 | 147.0 | 161.7 |
| **50 lbs.** | 0.8 | 1.6 | 2.4 | 3.2 | 4.0 | 4.8 | 5.6 | 6.4 | 7.2 | 8.0 | 8.8 |
| **100 lbs.** | 1.6 | 3.2 | 4.8 | 6.4 | 8.0 | 9.6 | 11.2 | 12.8 | 14.4 | 16.0 | 17.6 |
| **200 lbs.** | 3.2 | 6.4 | 9.6 | 12.8 | 16.0 | 19.2 | 22.4 | 25.6 | 28.8 | 32.0 | 35.2 |
| **500 lbs.** | 6.4 | 15.8 | 23.7 | 31.6 | 39.5 | 47.4 | 55.3 | 63.2 | 71.7 | 79.0 | 86.9 |
| **1000 lbs.** | 15.8 | 31.6 | 47.4 | 63.2 | 79.0 | 94.8 | 110.6 | 126.4 | 142.2 | 158.0 | 173.8 |
| **2000 lbs.** | 31.6 | 63.2 | 94.8 | 126.4 | 158.0 | 189.6 | 221.2 | 252.8 | 284.4 | 316.0 | 347.6 |
| **3000 lbs.** | 47.5 | 95.0 | 142.5 | 190.0 | 237.5 | 285.0 | 332.5 | 380.0 | 427.5 | 475.0 | 522.5 |
| **6000 lbs.** | 95.1 | 190.2 | 285.3 | 380.4 | 475.5 | 570.6 | 665.7 | 760.8 | 885.9 | 951.0 | 1046.1 |
| **12000 lbs.** | 190.2 | 380.4 | 570.6 | 760.8 | 951.0 | 1141.2 | 1331.4 | 1521.6 | 1711.8 | 1902.0 | 2092.2 |
| **20000 lbs.** | 317 | 634 | 951 | 1268 | 1585 | 1902 | 2219 | 2536 | 2853 | 3170 | 3487 |
| **40000 lbs.** | 635 | 1270 | 1905 | 2540 | 3175 | 3810 | 4445 | 5080 | 5715 | 6350 | 6985 |
| **70000 lbs.** | 1111 | 2222 | 3333 | 4444 | 5555 | 6666 | 7777 | 8888 | 9999 | 11110 | 12221 |

# COMMON MATERIAL DENSITIES

| Material | $\frac{kg}{m^3}$ | $\frac{\text{lbs}}{\text{ft}^3}$ |
|---|---|---|
| Aluminum | 2712 | 169 |
| Asphalt | 1041 | 65 |
| Brass | 8400 | 524 |
| Brick, common | 1794 | 112 |
| Bronze | 8780 | 548 |
| Cement, Portland | 1506 | 94 |
| Cement, Portland Set | 2010 | 125 |
| Chalk | 2195 | 137 |
| Clay (wet) | 3124 | 195 |
| Coal (anthracite) | 1554 | 97 |
| Coal (bituminous) | 1346 | 84 |
| Concrete Masonry | 2323 | 145 |
| Copper | 8940 | 558 |
| Glass | 3140 | 196 |
| Gold | 19320 | 1206 |
| Gravel | 1922 | 120 |
| Iron | 7850 | 490 |
| Kerosene | 817 | 51 |
| Lead | 11342 | 708 |
| Limestone | 2739 | 171 |
| Manganese ore | 3204 | 200 |
| Nitrates | 1602 | 100 |
| Oils, mineral | 929 | 58 |
| Paper | 929 | 58 |
| Petroleum, crude | 881 | 55 |
| River mud | 1442 | 90 |
| Sand | 1602 | 100 |
| Sandstone | 1442 | 90 |
| Silver | 10490 | 655 |
| Steel | 7850 | 490 |
| Tin | 7280 | 455 |
| Zinc | 7135 | 445 |

## SAMPLE AIR LIFT BAG PRE-USE CHECKLIST

Identification No:
……………………………………………………………………………………………………………

Safe working load:
……………………………………………………………………………………………………………

Bag type: Parachute / enclosed (delete as applicable)

Load test expiry date:
……………………………………………………………………………………………………………

Leak test expiry date:
……………………………………………………………………………………………………………

| **Items to be checked** | |
|---|---|
| **1 Check the general condition of the lift bag material** | |
| 1.1 | General condition/appearance of bag material/fabric and eyelets |
| 1.2 | Check inside of the bag for damage or debris, check condition of the dump line |
| 1.3 | Safe working load (SWL) is clearly shown on lift bag |
| 1.4 | Identification number is clearly shown on the lift bag |
| 1.5 | Details on certificate(s) agree with the identification number on the lift bag |
| **2 Check the general condition of the rigging** | |
| 2.1 | General condition/appearance of rigging items |
| 2.2 | Condition of all the web slings |
| 2.3 | Condition of the stitching retaining the web slings |
| 2.4 | Web slings are not crossed over or twisted |
| 2.5 | Condition of the masterlink(s) |
| 2.6 | Condition of the shackles |
| 2.7 | All shackle pins are secured in place (e.g. screw pin shackles ty-wrapped) |
| 2.8 | Web slings, shackles and master links are of an appropriate SWL for the bag |
| 2.9 | Details on certificate(s) agree with identification numbers on rigging items |
| **3 Check the functional items on the lift bag** | |
| 3.1 | Check the integrity of the inverter line attachment point(s) to the lift bag |
| 3.2 | Check that the length of inverter line is adequate |
| 3.3 | Confirm that the inverter line is clearly different from the dump line |
| 3.4 | Condition/appearance of the dump valve |
| 3.5 | Test the dump valve function – pull the dump line to test the valve action |
| 3.6 | Confirm the dump valve is free from blockage/mud plugs |
| 3.7 | Confirm the dump valve O-ring seal is in place |
| 3.8 | Check that the length of the dump line is adequate |
| 3.9 | Confirm that the dump line is clearly different from the inverter line |
| 3.10 | Condition/appearance of the quarter turn valve(s) |
| 3.11 | Function the quarter turn valve handle(s), confirm valve(s) opens and closes |
| 3.12 | Confirm quarter turn valve(s) are free from blockage/mud plugs |
| 3.13 | Condition/appearance of relief valve(s) |
| 3.14 | Confirm relief valve(s) are free from blockage/mud plugs |

# 5.33 UNDERWATER EXCAVATION OPERATIONS GUIDELINES

## 5.33.1 PURPOSE

1. The purpose of this document is to identify potential hazards and recommend safety precautions when conducting underwater operations below the mud line (deep ditch).
2. This recommended procedure is applicable for all sectors of the commercial diving community, both inland and offshore.

## 5.33.2 FACTORS TO CONSIDER

1. When performing a variety of tasks, divers are often required to excavate areas or enter excavated areas.
2. Hand-jetting and airlifting material from the natural bottom can pose a threat of burial.
3. Extra precautions should be taken through the performance of pre-dive safety assessments.
4. Variations in bottom conditions can cause changes in stability, which might warrant a more conservative approach to operations than the outlined recommendations of this document.

No standard can cover all potentialities that might be encountered. JHAs, common sense and extra attention to detail by the entire dive team are to be considered essential components for approaching operations of this nature. JHAs should be updated as work progresses to reflect the current conditions.

## 5.33.3 DEFINITIONS

**Ditch:** An excavation area/trench/channel created to gain access to the working area.

**Deep ditch:** Any excavation or channel that is deeper than 6 feet (2 meters) from natural bottom (top of the subsurface ditch) to the bottom of the subsurface ditch.

**Natural bottom:** Depth of the seabed prior to any excavation.

## 5.33.4 RESPONSIBILITY

The dive supervisor is responsible for the welfare and safety of the dive team. The diver is responsible for ensuring that he or she is performing the assigned tasks in a safe and responsible manner.

## 5.33.5 POTENTIAL HAZARDS ASSOCIATED WITH DEEP-DITCH OPERATIONS

1. Ditch wall collapses and traps the diver and/or his or her umbilical.
2. Unintentional creation of a tunnel by the diver while hand-jetting.
3. Malfunction of jet nozzle or other component of hand-jetting tool.
4. Injury to diver or his or her equipment due to jet hose or water directed from the hand-jet.
5. Injury to topside personnel due to component malfunction of hand-jetting equipment.
6. Injury to diver or damage to his or her equipment due to airlift suction.

## 5.33.6 RECOMMENDED WAYS TO MITIGATE POTENTIAL HAZARDS ASSOCIATED WITH DEEP-DITCH OPERATIONS

1. Situational awareness on the part of the diver and topside personnel:

The diver should always inspect the condition of the ditch wall prior to beginning or resuming work.

a. Hose management/regular communication.

b. Diver should routinely ensure that an adequate slope to depth ratio be established and maintained. At a minimum, it is recommended that for every 1 foot/meter excavated downward, 3 feet/meter need to be excavated in an outward direction (3:1 ratio).

2. Periodic and regular physical checks need to be made by the diver on his or her exact location. The diver should periodically remove himself or herself from the ditch and return to natural bottom to assess any potential hazards to him or herself, his or her umbilical, or hand-jet equipment.

There are no guarantees that equipment malfunctions will not occur during the course of operations. Routine pre-dive and post-dive checks of all equipment and systems are the best ways to guard against malfunction.

3. The diver should always ensure that he or she is capable of handling the force of pressure being emitted from the jet nozzle. Proper balance, footing and positioning of the diver is the best way to ensure that back or frontal spray from the jet nozzle does not injure the diver or damage his or her equipment.

**Sending gas to the diver's pneumo and partially activating the diver's "free flow" are other recommended practices while conducting deep-ditch operations.**

### 5.33.7 MINIMUM PERSONNEL REQUIREMENTS FOR DEEP-DITCH OPERATIONS

On all deep-ditch operations, a minimum of five crew members are required, consisting of:

- One diving supervisor.
- One diver.
- One standby diver.
- Two diver/tenders.

(The stand-by diver's equipment and thermal protection shall be dressed/outfitted to at least equal that of the diver.)

### 5.33.8 MINIMUM EQUIPMENT REQUIREMENTS FOR DEEP-DITCH OPERATIONS

Redundant jetting equipment and a greater length of jet hose shall be present at the dive site. In addition, the redundant jetting equipment shall be primed and running at an idle pressure at all times that the primary system is in use.

**NOTE:** Deep-Ditch Operations are considered construction work. A helmet that totally surrounds the diver's head is the only acceptable form of head gear for personnel working in this type of setting.

### 5.33.9 PERSONNEL QUALIFICATIONS

All members of the dive team should be trained and experienced for the tasks to be performed. In the case of deep-ditch operations, underwater personnel should be properly screened to ensure that they understand the scope of work to be performed, the potential hazards involved, and the procedures for rescuing a trapped or injured diver.

### 5.33.10 HAND JETTING ON PIPELINES – PIPE MOVEMENT

**NOTE: Hand jetting on a live pipeline requires several factors to be considered, such as the contents of the pipeline, external and environmental factors, as well as the age, condition and diameter of the pipeline.**

**The following guidelines are based on CFR 49 Transportation of Hazardous Liquids by Pipeline Subpart F – Operation and Maintenance. (See below)**

#### 195.424 Pipe Movement

(a) *No operator may move any line pipe unless the pressure in the line section involved is reduced to not more than 50 percent of the maximum operating pressure.* **Hand jetting to expose a live pipeline does not require a reduction in pressure.**

(b) No operator may move any pipeline containing highly volatile liquids where materials in the line section involved are joined by welding unless:

(1) Movement when the pipeline does not contain highly volatile liquids is impractical;

(2) The procedures of the operator under §195.402 contain precautions to protect the public against the hazard in moving pipelines containing highly volatile liquids, including the use of warnings, where necessary, to evacuate the area close to the pipeline; and

(3) The pressure in that line section is reduced to the lower of the following:

(i) Fifty percent or less of the maximum operating pressure; or

(ii) The lowest practical level that will maintain the highly volatile liquid in a liquid state with continuous flow, but not less than 50 p.s.i. (345 kPa) gage above the vapor pressure of the commodity.

(c) No operator may move any pipeline containing highly volatile liquids where materials in the line section involved are not joined by welding unless –

(1) The operator complies with paragraphs (b) (1) and (2) of this section; and

(2) That line section is isolated to prevent the flow of highly volatile liquid.

**Both operator and contractor should perform a thorough risk assessment analysis, ensuring that all of the above requirements are met and that there are no other external conditions which could compromise adherence of this Code of Federal Regulation. It is not recommended that live pipelines be moved in an upward direction (lifted).**

# 5.34 HIGH-PRESSURE WATER BLASTING

## 5.34.1 INTRODUCTION

High-pressure water jets are employed in a variety of ways to accomplish cleaning and cutting tasks underwater. These units typically operate at pressures of 1,000 to 40,000 psig and higher.

**Water blasters are dangerous and can cause serious injuries. Recommended practices and procedures do not replace the proper training necessary to operate high-pressure water blasting systems. Injuries caused by water blasters are highly susceptible to infection and should be given immediate treatment. Anyone who suffers an injection should immediately stop working, report to their supervisor and seek medical advice on treatment.**

## 5.34.2 GENERAL

- Personnel assigned to water blasting operations, particularly diving personnel, should be trained by qualified personnel and properly demonstrate their knowledge and ability to perform a task prior to being required to do so.
- Serious harm and injury may result from the misuse of water-blasting equipment and from the use of improperly selected fittings, hoses or attachments. All components of the system should be checked against the manufacturer's instructions to ensure that they are compatible and of the correct thread size and pressure rating for the intended service.
- All dive team members (divers, tenders and supervisors) should be familiar with the equipment intended for use and with the hazards associated with their operation.
- Prior to operation, all equipment should be inspected for damage and deterioration, with particular attention paid to high-pressure hoses, fittings and gun trigger function.
- Prior to use in diving operations, the water-blasting equipment should be fully assembled and functionally tested, including emergency shutdown or dump valve operation.

## 5.34.3 PLANNING AHEAD FOR WATER BLASTER SAFETY

- Be a good observer. Look out for yourself and others. Review what to look for and act on what you see. Use your Stop Work Authority.
- JHA: Unsafe work conditions and unsafe behavior are the main reasons for injuries and accidents. Identify and minimize risk, and assign responsibilities to produce a safe working environment.
- Stop Work Authority: Every worker has the responsibility to stop an unsafe act or task. Shut down the operation and reassess the potential problem. Revise your JHA and resume safe operations.
- Report all incidents: Properly report all incidents, document the event, and obtain medical care if needed. Reporting incidents, no matter how minor, is the key to injury prevention.

## 5.34.4 POTENTIAL HAZARDS

- The safety point for water blasters is the rupture disc. Do not use coins to replace the disc. There are reasons that cause discs to rupture (wrong tip or blockage).
- Using the wrong tips in the underwater gun will rupture the disc or lower discharge pressure.
- Diver inadvertently directs the front pressure stream onto himself or herself, his or her umbilical, or equipment.
- The baffle tube comes loose from the control valve block and exposes the retro nozzle assembly. Unaware of the situation, the diver continues blasting and inadvertently directs the stream from the exposed retro nozzle onto him or her.
- A hose or fitting failure allows leaking pressure stream to contact and injure topside personnel or diver.
- Topside personnel inadvertently direct the front or retro pressure stream onto themselves or others when preparing, testing or using the system.
- Airborne debris created when using the water blaster topside causes persons in the area to have particles carried by mist into their eyes.
- Topside personnel strain their backs while handing hose.
- Water supply to the pump is used up, shut off or blocked, and the pump overheats and damages occur. (The water cools and lubricates the pump machinery and, if the pump is operated dry, it will quickly heat up and seize.)
- Tools or items of equipment fall or are dropped and cause injury to personnel or damage to the pump.

### 5.34.5 PRIOR TO COMMENCEMENT OF UNDERWATER WATER BLASTING OPERATIONS

A survey of the underwater site should be undertaken to identify potential hazards. A job hazard analysis should be done or reviewed by the dive team.

The job hazard analysis should include, but not be limited to, the following provisions:

- Tending of the diver's umbilical and the high-pressure water hose during water blasting operations.
- System to be pressurized only on request from the diver.
- Ability to quicklyshut down pressure to the gun.
- System pressure is shut down prior to the diver leaving the worksite.
- A thorough risk assessment analysis must be conducted if more than one diver is performing high pressure water blasting operations at the same time. Safe distance and other considerations must be provided to each diver and their applicable equipment.
- Due to the high noise levels generated, commands and signals should be agreed to and reviewed between the diver and topside.
- Ear protection for the diver is necessary. Limit diver exposure time due to the noise hazard.
- Trigger mechanism shall be of a dead-man type and shall not be tied back or wedged in the flow or "open" position under any circumstances.
- Careful check of the retro jet nozzle guard, as this could present a hazard to the diver and his or her hose if it is not properly guarded and diffused.
- Nozzle selection should be appropriate for the work intended (the smaller angle of rifle barrel nozzle being the most dangerous due to its cutting ability).
- The ADCI recommends against the miss-matching of high-pressure hoses, water blast guns and any high-pressure connections between different company units.

## 5.35 PENETRATION DIVING

**PENETRATION DIVES SHALL BE RIGOROUSLY RISK ASSESSED.**

### 5.35.1 DEFINITIONS

**Penetration dive:** A dive that requires a diver to access an area that is both a physically confining space and one in which there is no direct access to the surface or bell for recovery of the diver from the water by the tender.

**Physically confining space:** Any underwater space that would restrict the diver's ability to rotate himself or herself head to toe, 180 degrees, in any plane.

**Direct access to the surface:** A dive location where the diver can be easily pulled to the surface by a surface tender, or to a bell by an inside bell tender. This does not necessarily mean that there is not an obstruction on the surface directly above the diver during the dive, but that there is nothing to restrict the diver from being pulled back to the point of entry at the water surface or bell by a topside tender or bell tender.

**Diver working around corners:** A situation where the umbilical may become fouled or where line pull signals may become dissipated due to the dive site configuration creating an impossibility of a straight line pull between a surface tender and the diver.

**Confined space:** A confined space is an enclosed space and is descriptive of topside conditions only. In certain instances, in order to access the dive site, the dive crew may have to transit or work from a confined space. Generally, a confined space:

- Is large enough and arranged so an employee could fully enter the space and work.
- Has limited or restricted entry or exit. Examples are tanks, vessels, silos, storage bins, hoppers, vaults, excavations and pits.
- Is not primarily designed for human occupancy.
- Is not flooded.

All topside operations performed from/in confined spaces shall conform to appropriate regulatory requirements.

### 5.35.2 PERFORMING PENETRATION DIVING

When performing penetration diving, if the entrance to the penetration is underwater and not readily accessible from the surface, then the diver shall be tended at the entrance of the penetration by an in-water tender at all times. The purpose of the in-water tender is to tend the penetrating diver's umbilical and to assist should the diver require assistance in the event of a fouled umbilical or entrapment.

In these conditions, the dive team must include an additional tender/diver, as well as a third umbilical for the topside standby diver.

When any diver is working around corners where the umbilical is likely to become fouled or line-pull signals may be dissipated, other in-water diver/tenders may be sent down to tend the lines of the first diver at the obstructions and to pass along any line-pull signals.

### 5.35.3 MINIMUM PERSONNEL REQUIREMENTS FOR PENETRATION DIVING OPERATIONS

- One diving supervisor.
- One diver.
- One in-water tender (standby diver).
- Two topside tenders.

(One of the topside tenders can act as the topside Standby Diver)

### 5.35.4 EXAMPLES OF PENETRATION DIVING

- The most common example of a penetration dive is that of a diver entering a pipe and traveling along its interior. This would generally meet both criteria listed above for penetration diving (physically confining space and no direct access to the surface).
- Generally, working under a vessel or barge would not be considered a penetration dive, as the diver can usually be easily pulled to the surface at the location of the topside tender.

**There is a clear and distinct difference between working beneath a vessel and working in a pipeline. In the former case, the diver may be directly retrieved by the surface tender without danger of entrapment or entanglement as the umbilical is generally maintained in a horizontal direct line to the diver. In case of a diver entering an underwater pipeline, the umbilical will often turn a corner at the entrance to the pipeline, or even within the pipeline, and therefore it must be tended at such points by another diver acting as in-water tender. When performing long penetrations, additional in-water tenders may be needed, and calculations should be performed to ensure adequate volume and pressure of gas is delivered to the diver.**

## 5.36 POTABLE WATER DIVING OPERATIONS

### 5.36.1 GENERAL

The intent of these guidelines is to address some of the more obvious requirements necessary for the conduct of safe commercial diving operations in potable water tanks and reservoirs.

**All equipment and manning levels should be considered the recommended minimum for approaching this diving application, based on one dive and any applicable decompression required. Increased manning levels and additional equipment may be required for any diving in excess of one dive and any decompression required. Proper pre-job planning shall be conducted to ensure that the necessary levels of personnel and equipment are available for diving operations.**

### 5.36.2 OPERATING PROCEDURES

#### 5.36.2.1 Non-isolated Storage Facility Operations

While the water facility operator may choose to isolate the facility from the system during underwater maintenance activities, it is recognized that isolation of the storage facility in order to undertake routine underwater maintenance may be inconvenient, or even impossible, as a result of system operating or design limitation.

Any diving operation conducted with the water storage facility in a non-isolated status may present potential hazards to the diver. This is due to the differential pressure created by the head of water versus the decreased pressure at the valve outlet location.

Under such conditions, a thorough JHA evaluation of the situation must be considered during planning and assessment and proper steps taken to ensure that the diver and equipment will not be subjected to the differential pressure. (See Section 5:17: Differential Pressure.)

Steps must be taken to ensure that the diver is aware of the fact that a particular valve will be open and that a differential pressure hazard exists. Care must be taken to furnish the diver with a detailed location of open valves and instruct the diver to remain clear of any such openings. The water facility operator MUST take part in discussions relative to diver safety in a non-isolated facility and be prepared to take appropriate action as agreed.

### 5.36.3 ISOLATED STORAGE FACILITY OPERATIONS

In the event that the water facility operator elects to isolate the water storage facility for the conduct of underwater maintenance activities, the facility shall be removed from service and isolated from the system prior to the commencement of any diving activity. All system primary and secondary inlet and outlet valves must be verified as locked and tagged "closed" by the designated person in charge (diving supervisor) of the diving operation.

In the event that storage facility valves must be inspected during diving operations, system valves farther upstream or downstream must be closed.

All valves critical to isolation of the water storage facility must be tagged in either the open or closed position as agreed during planning and assessment. Security of the valve(s) position must be assured, and that no valve can be opened without the expressed permission of both the water facility's designated person in charge and the designated person in charge of the diving operation (diving supervisor).

Divers shall not enter the riser pipe in an elevated tank unless the tank has been isolated, locked, and tagged in accordance with Lockout/Tagout procedures.

### 5.36.4 EQUIPMENT AND PERSONNEL REQUIREMENTS

**NOTE: It is strongly recommended that equipment used in these operations be solely dedicated to potable water operations only.**

#### 5.36.4.1 Equipment

All diving and other equipment used for underwater inspection of potable-water storage facilities shall, wherever possible, be dedicated for that purpose only. If not feasible, all equipment intended for use in a potable-water storage facility shall be certified as having been thoroughly disinfected prior to arrival at the job site, and the dressed diver shall again be disinfected at the potable-water site.

Equipment to be used in potable-water storage facilities should, at a minimum, be disinfected by first removing all visible debris, dirt or other substances and then totally immersed in 200 PPM chlorine solution for a minimum of two minutes prior to use in potable water. Total immersion means that all outside surfaces of the equipment that will have contact with the potable water must be in continuous contact with the 200 PPM chlorine solution. The dressed divers shall be sprayed with a 200 ppm chlorine solution immediately before entering the water. Further information on disinfection procedures is available from the ANSI/AWWA Disinfection Standard.

Any equipment previously used in a contaminated water diving environment should not be used inside a potable water facility.

**Scuba shall not be used in potable water facility operations.**

- **Diver clothing.** Each diver shall wear a vulcanized rubber or other smooth surface material dry suit in good condition, free from tears, scrapes, damaged areas or other imperfections that may impair the integrity of the suit or serve as a site for bacteriological contamination. Further, the diver's dress, including the diving helmet and suit, shall provide complete encapsulation and isolation of the diver's body from the potable water.
- **Diving helmet.** The diver shall wear a diving helmet (a hard helmet that totally surrounds the diver's head in a dry environment) that is equipped with live voice communications and a neck dam that can be sealed to the suit, and can be fitted to accept a bailout system with shut-off valve. Further, the helmet shall, just as all of the diver's equipment and clothing, be considered a potential source of bacteriological contamination. The use of a diver band mask (any configuration of mask and breathing regulator that does not totally surround the diver's head with a dry helmet) shall be specifically prohibited except in the case of an emergency.

### 5.36.5 SAFETY

**No standard can cover all situations that might be encountered. JHAs, common sense and extra attention by the entire dive team are considered essential components for approaching operations of this nature. JHAs should be updated as work progresses to reflect the current conditions.**

### 5.36.6 GENERAL REQUIREMENTS

- For all diving operations intended to take place in an elevated structure, a means of rescue of personnel from the top of the structure shall be provided. A safe and effective means of lowering injured personnel from the top of such tanks will be provided.
- A means for rescue of diving personnel from an enclosed space or elevated height must be furnished as applicable, when required.

**When diving operations are being conducted on elevated tanks, increased manning levels shall be considered.**

## 5.37 CONTAMINATED WATER DIVING OPERATIONS

**All equipment and manning levels should be considered the recommended minimum for approaching this diving application, based on one dive and any applicable decompression required. Increased manning levels and additional equipment may be required for any diving in excess of one dive and any decompression required. Proper pre-job planning shall be conducted to ensure that the necessary levels of personnel and equipment are available for diving operations.**

**The information presented in this section has been generated as guidance material only that must be considered when planning the conduct of contaminated water diving operations.**

**A primary consideration during contaminated water diving operations is to minimize the length of time during which members of the dive team are exposed to contaminants. Dives should be scheduled to require no in-water decompression so as to limit the diver's exposure to waterborne hazards.**

### 5.37.1 TRAINING

a. All personnel who are likely to participate in contaminated water diving operations should receive training consistent with regulatory requirements for the area where operations are to be conducted, such as 29 CFR 1910.120 (U.S. OSHA) – Hazardous Waste Operations and Emergency Response (HAZWOPER).

b. Specific training must be furnished in:

- Dry suits.
- Personal protective equipment for topside and diving personnel.
- Decontamination procedures, including preparation of the disinfectant or other solution intended for use.
- Decontamination of personnel and equipment used during operations.

### 5.37.2 SITE EVALUATION

When operations will take place where the water is suspected or known to be contaminated, a site assessment must be conducted. This assessment should include:

- Any suspected contaminants and potential hazards.
- Testing of the dive environment: It is not always possible to tell whether an environment is contaminated either by sight or smell. Any diving environment should be approached with caution, and when contamination is suspected, the water should be tested prior to commencing operations.
- Wind: In situations where there may be toxic fumes, the dive station, compressor and topside personnel must be situated up-wind from any source of contamination to the air.
- Current: Both on the surface and underwater, the diver should approach any known point-source of contaminant from the up-current side whenever possible. This will allow the current to carry contaminants away from the diver.
- Perimeter: Whenever possible, a perimeter should be established around the dive station and dive site to keep unprotected persons away from any possible contamination.
- Established zones: Zone management should be employed when applicable to keep unprotected personnel and equipment outside of the hot zone.

### 5.37.3 TOPSIDE PERSONNEL PROTECTIVE EQUIPMENT: EPA SELECTION GUIDELINES

To aid in the selection of complete protective ensembles, including chemical protective clothing and respirators, the United States Environmental Protection Agency's (EPA) Office of Emergency and Remedial Response has designated four levels of chemical hazards, ranging from extremely dangerous or unknown (Level A) to situations where only basic work-wear (Level D) is the required protection.

The OSHA standard recommends the use of these guidelines, which can assist employers in complying with the protective equipment requirements of the standard.

The following is a brief review of the EPA guidelines. These are explained in greater detail in Appendix B of the OSHA standard and Table 1 (in this section).

- **Level A** calls for a vapor-tight suit (total-encapsulating) that is non-permeable to the chemicals to which a worker will be exposed. Also necessary is an approved, positive-pressure, self-contained breathing apparatus (SCBA) or a NIOSH-approved, positive-pressure air-line respirator with escape SCBA having no less than a five-minute air cylinder. Outer and inner chemical-resistant gloves and chemical-resistant boots with a steel toe and shank should also be used.
- **Level B** necessitates the same level of respiratory protection and complete skin coverage as Level A. However, protective clothing does not have to be vapor tight.
- **Level C** calls for a full-face piece, or half-mask air-purifying respirator; splash garments used with outer and inner chemical resistant gloves; and chemical resistant boots with a steel toe and shank.
- **Level D** calls for basic work-wear such as long sleeve coveralls, hard-soled shoes and face shields or goggles.

a. Before any diving operation is conducted in contaminated water, a risk assessment is vital. Personal protective equipment (PPE) must be selected based on its known ability to protect workers from the specific hazards present or suspected. This applies to the diver and the topside personnel. There are four different categories of topside PPE, from the least protective (Level D) to total encapsulation (Level A). Requirements for these levels are set forth in Table 1 in this section.

b. The key variables that must be considered when selecting PPE are:
   - Identification of the hazard(s).
   - Route of potential hazard to employees, e.g., inhalation, skin absorption, ingestion and eye or skin contact.
   - The performance of PPE materials, seams, visors and all other vital components
   - Matching PPE durability of materials such as seam, tear, burst and abrasion strength to dive site-specific conditions.
   - Matching site environmental conditions to PPE effect on employees (e.g., heat stress, hypothermia, dehydration, duration of task, etc.).
   - Equipment selection (PPE). Site-specific variables must be considered and protection geared to the worst case situation if those variables are not positively identified. The more that is known about the site, the easier it will be to customize suitable PPE to ensure protection of the dive team topside members.

<table>
<tr><th colspan="5">TABLE 1<br>GUIDELINES FOR SELECTION OF PERSONAL PROTECTIVE EQUIPMENT</th></tr>
<tr><th>EPA Level</th><th>Respiratory Protection</th><th>Protective Clothing</th><th>Hand and Foot Protection</th><th>Additional Protection</th></tr>
<tr><td>A</td><td rowspan="2">An approved positive-pressure, full face-piece, self-contained breathing apparatus (SCBA)<br>or<br>An approved, positive-pressure, supplied-air respirator with escape SCBA (minimum 5-minute duration)</td><td>Totally encapsulating chemical protective suit specifically designated to resist permeating by chemicals that are encountered</td><td rowspan="3">Gloves: Outer and inner chemical-resistant gloves<br><br>Boots: Chemical-resistant, with steel toe and shank</td><td>• Coveralls<br>• Long underwear<br>• Hard hat<br>• Two-way radio communications system</td></tr>
<tr><td>B</td><td rowspan="2">Hooded chemical-resistant clothing made of materials resistant to the chemicals encountered (overalls and long-sleeved jacket; coveralls; one-or two-piece chemical splash suit; disposable chemical-resistant overalls).</td><td>Above, plus:<br>Face shield<br>Boot covers (disposable, chemical-resistant)</td></tr>
<tr><td>C</td><td>An approved full face-piece or half-mask air-purifying respirators</td><td>Above, plus: all items that precede it Escape tank</td></tr>
<tr><td>D</td><td></td><td>Coveralls.</td><td>Boots: Chemical-resistant, with steel toe and shank</td><td>Above, plus: all items that precede it Safety glasses or splash goggles<br>Gloves</td></tr>
</table>

### 5.37.4 DIVER-WORN OR CARRIED EQUIPMENT AND ACCESSORIES

a. Selection of the diver-worn equipment must be based on the level of contamination protection required. The following equipment configurations are only recommendations. Responsibility for selection of equipment and diving technique must be made by the persons engaged in the diving activity as identified in the dive plan and/or job safety analysis.

b. Equipment that supports the diver must also be compatible with the contaminants that may be encountered.

c. There are three levels of protection for diver-worn equipment and accessories, from the most protective (Level One) to the least protective (Level Three). Requirements for these levels are set forth in Table 2 in this section.

d. All diver-worn equipment should be tested for integrity and function prior to the diving operation.

| TABLE 2<br>DIVER-WORN OR CARRIED EQUIPMENT AND ACCESSORIES | | |
|---|---|---|
| **LEVEL ONE<br>(Most Protective)** | **LEVEL TWO** | **LEVEL THREE<br>(Least Protective)** |
| • For diving in waters containing biological contamination, petroleum fuel, lubricating oils and industrial chemicals known to cause long-term health risks or death<br>• Helmeted surface-supplied diver with mated non-porous dry suit with attached boots, gloves, and a return line exhaust or double exhaust valve system<br>**NOTE:** The use of Level One protection should take into consideration the chemical compatibility of the equipment being used and the resultant permeation of waterborne contamination into the equipment. (Consult manufacturer's data). Diving in waters containing strong chemicals or nuclear contamination where even minor exposure could cause a serious threat will require special consideration and planning, equipment precaution, and training | • Biological or chemical contamination that will cause short-term health effect but will not cause lasting injury, disability or death<br>• Surface-supplied umbilical with dry suit with attached and sealed hood, gloves and boots<br>• Full-face mask that overlays the dry suit hood face seal | • Recommended for diving in waters that are considered to pose a minimal health risk<br>• Scuba/surface-supplied umbilical with half-mask or full mask, chafing overalls, and hand and foot protection |

**Any actual or suspected breach of a Level One diving system is cause for the immediate termination of diving operations.**

### 5.37.5 DECONTAMINATION PROCEDURES

In certain highly contaminated diving situations, the following procedures may be applied but are not necessarily applicable for every job:

a. The area surrounding the diving control station may be divided into three zones for proper isolation of contamination. The zone immediately surrounding the point of water entry/exit is deemed "high contamination." The zone where divers and gear progress after initial decontamination is termed "low contamination." The final zone into which the divers progress after they have been decontaminated and all diving gear removed is "clean."

b. An effective color-coding system may be employed to communicate clearly the demarcation point of the decontamination area. One system might be to use red to identify all "high" areas, yellow for "low" areas and green for "clean" areas. If at all feasible, the "clean" zone should be positioned up-wind of the contaminated zones.

c. **Initial freshwater rinse:** Spray off bulk of contaminants using high-pressure, clear freshwater rinse. If effluent does not require capture, begin hosing diver as he or she initially exits water to limit quantity of contaminants transferred to the dive station.

- Take precautions to direct water flow away from potential points of leakage of diver's rig, such as exhaust valves, seal junctions, etc. A high-pressure jet of water directed at such potential breach points may inject contaminants inside of the protective gear and into contact with the diver. Care should be taken to ensure the removal of the bulk of contaminants at this stage in order to afford the greatest efficacy of subsequent decontamination steps.

d. **Oversuit:** If a reasonable expectation exists for encountering bulky, adherent contaminants in the course of a dive, the use of a disposable oversuit is strongly encouraged. Disposable, hazardous material protective suits may be secured to a diver after he or she has been outfitted with the entire diving rig.

- No effort to make the oversuit water-tight should be attempted. Such action could complicate the dive by creating air pockets that could affect buoyancy of the diver. As the diver arrives on the dive station, the oversuit should be cut away to allow for decontamination of the diver and equipment. At this time, removal of dive gear such as harnesses, weight belts, emergency gas supply (bailout) tanks, etc., should be performed with these items themselves being properly decontaminated.

e. **Scrub down:** After the diver has been initially rinsed and his or her equipment removed, he or she may be scrubbed with a stiff-bristle synthetic brush and a cleaning solution as applicable. Long-handled brushes may facilitate the cleaning process. Hand-held brushes may be employed for detailed cleaning of the dive helmet and the neck-dam interface.

- Once the diver has been thoroughly scrubbed with cleaning solution applied from head to toe, he or she should be rinsed with fresh water. Care should be taken to ensure the diver has been cleaned of all visible contamination, most notably in the area adjacent to the neck-dam, helmet and dry suit.
- The composition of the cleaning solution should be appropriate for the contaminant to be removed.

f. **Undress diver:** Once the diver has been adequately decontaminated and moved into the "low contamination" zone, the dive gear should be removed. First, disconnect the locking mechanism from the helmet to dry suit and remove the helmet. Then, remove the dry suit and gloves and finally, the undergarments.

- If there are no indications that the diving rig has been breached during the dive, the diver may proceed to the "clean" zone and, if applicable, take a post-dive shower.
- If there are positive indications of dermal exposure to contaminants, additional decontamination measures may be required.

g. **Clean equipment:** After removal from the diver, all equipment should undergo secondary decontamination.

h. **Capture effluent:** In some circumstances it will be necessary to capture all fluids used to rinse, wash and re-rinse the diver and equipment and dispose of them in a manner appropriate for hazardous materials. If necessary, the above procedures will need to be altered to ensure that all decontamination procedures take place within a water-impermeable capturing area.

### 5.37.6 HAZARD EVALUATION AND IDENTIFICATION

a. When the threat of a chemical hazard is suspected, consider conducting a historical review of the site. Items such as spill history, known chemicals present, volume of chemicals, active discharges, air quality, present and past nature of operations, and presence of extremely hazardous substances should be examined. Facility safety officers, plant supervisors or technicians may provide useful information.

b. When planning contaminated water diving operations, water temperature needs to be taken into account when determining the proper equipment to be used.

c. Check with local, state or federal water quality agencies for current advisories on biotoxins, waterborne pathogens, microbial contamination, fish or shellfish advisories, beach closures or storm events, any of which may indicate pollutants to be present.

d. When hazardous contaminants are suspected, consider water or sediment sampling and analysis. The selected laboratory can provide proper containers and procedures for sample collection, handling and shipping.

e. If the pollutants have been identified, rapid on-site test kits for selected chemicals in sediment or water are, in some cases, available.

**If severe contamination is known to be present at the planned site of diving operations, consideration should be given to using an ROV if possible.**

f. Hand-held detectors for monitoring a class of airborne chemicals, such as volatile organics, can be utilized for:

- Initial entry into the staging area during mobilization if the air quality is unknown.
- Continuous monitoring with alarms during diving operations to rapidly notify the participants if air quality changes.
- Scanning the diver upon water exit and after decontamination to determine if contaminants are present.

g. Lists of very dangerous chemicals that may readily penetrate diving equipment or cause substantial harm after a brief exposure can be obtained from the suit manufacturer. If a diver or topside crew member suspects exposure, blood, urine or other biological samples may be gathered for medical review.

## 5.38 HYDROGEN SULFIDE ($H_2S$) RECOMMENDED GUIDELINES

### 5.38.1 PURPOSE

This purpose of this procedure is to provide guidelines for identifying, training, and monitoring the health and safety of personnel that could potentially be exposed to Hydrogen Sulfide ($H_2S$) vapors or gasses.

**NOTE: These are minimal guidelines. Contractors and operators should seek current directives and procedures from appropriate sources.**

### 5.38.2 SCOPE

Thes procedure outlines the equipment required for working on projects with potential $H_2S$ contamination, recommended evacuation procedures, alarms for $H_2S$ detection, as well as training and medical guidelines.

### 5.38.3 RESPONSIBILITY

Contractors are responsible for ensuring that all components are in place for compliance of these guidelines. They are also responsible for ensuring that the proper training, qualification, certification, and medical requirements have been met by personnel. HSE departments should make available to company personnel any pertinent information on the job site to ensure compliance. It is also the responsibility of the contractor to establish an "$H_2S$ Evacuation / Contingency Plan" that can be tailored to specific projects when necessary. It is recommended that a formal Management of Change (MoC) be performed should any changes be required to the above mentioned evacuation / contingency plan.

## 5.38.4 PROCEDURE

### 5.38.4.1 Definition

Hydrogen Sulfide ($H_2S$) is a colorless, very toxic, flammable gas that has the characteristic odor of rotten eggs at concentrations up to 100 parts per million. Depending on environmental conditions $H_2S$' characteristic odor might not be detected, despite the gas being present. $H_2S$ is also referred to as "sour gas" or "sewer gas". It is not restricted to any one area or sector of the commercial diving industry. $H_2S$ is invisible and is capable of breaking down such materials as steel and rubber.

- At 200ppm – Symptoms: burning of eyes and throat, and severe headaches
- At 600ppm – lethal without immediate medical treatment
- At 1000ppm – lethal with little chance of survival

### 5.38.4.2 $H_2S$ Operational Guidelines

All projects with the potential for $H_2S$ contamination should have a $H_2S$ contingency plan that is tailored to the area and scope of work to be performed. Personnel should be familiar with the plan and trained and qualified to implement it.

It is recommended that the following guidelines be followed for personnel, equipment, and the implementation of contingency plans where $H_2S$ may present a hazard to operations:

- Personnel should be trained and familiar with OSHA 29 CFR 1910.134 outlining respiratory protection. Self Contained Breathing Apparatus (SCBA) should be used.
- Emergency muster points should be established for personnel with the proper respiratory equipment available.
- Scheduled drills should be conducted during the course of the project. It is also recommended that scheduled drills be conducted periodically for all project personnel.
- All equipment (alarms, breathing apparatus, compressors, HP bottles, and emergency escape packs, etc.) should be available at the project location. This equipment should be inspected prior to mobilization and documentation of its inspection should be available at the project location for review.
- All $H_2S$ alarms should be treated as an actual release.
- After any release all areas of the job site should be thoroughly checked and all holds ventilated. Re-entry to the job site requires verification of no presence of $H_2S$.

### 5.38.4.3 Diving Operations

If the $H_2S$ alarm is activated:

- All diving operations are to be aborted.
- All topside personnel should be outfitted in SCBA equipment or BIBS.
- All divers should be switched to emergency breathing gas and begin ascent to the surface. Divers in saturation should be returned to the saturation diving complex.
- The "$H_2S$ Evacuation / Contingency Plan" should be put into effect immediately.
- Communication and coordination between the Dive Supervisor and Vessel Captain/Barge Superintendent will determine vessel or barge movement. For land based operations the Dive Supervisor will interface with designated personnel as outlined in the job specific contingency plan. The job specific contingency plan should be completed by the Contractor.

$H_2S$ Project Specific Contingency plan should contain:

- Project location
- Client representative information
- Vessel(s) information
- Contact names and numbers for the client and all project managers
- Mobilization dates of the project
- Sub-contractor information (if applicable)
- Dock support information
- Equipment and training information
- Emergency plan and contacts

## 5.39 UNDERWATER SHIP HUSBANDRY (UWSH) FOR CARGO SHIPS/ FREIGHTERS

### 5.39.1 PURPOSE

The purpose of this section 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 cargo ships/freighters (general cargo vessels, container ships, tankers, dry bulk carriers, multi-purpose vessels, reefer ships), mega-ships, MODUs, and cruise 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.**

#### 5.39.2 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.

#### 5.39.3 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.

#### 5.39.3.1 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 propellors, 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.**

### 5.39.3.2 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.
- 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.

### 5.39.4 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.

### 5.39.5 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.)

## 5.39.6 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 O2 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.**

## 5.39.7 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 O2 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.

## 5.40 GUIDELINES FOR DELTA-P DIVING IN POWER GENERATING FACILITIES

### 5.41 Background

Between June 2019 and July 2021, there were five diving fatalities that occurred at power-generation facilities as a result of differential pressure (Delta-P). At the request of the OSHA's Office of Maritime Enforcement, the Association of Diving Contractors International (ADCI) formed a task force consisting of ADCI, OSHA, contractors, the USACE, sonar experts, and facility operators to address the hazards associated with Delta-P.

### 5.42 Purpose

The purpose of this checklist is to provide best industry practices in a clear and complete format for dive operations at power-generating facilities where Delta-P hazards exist. It is a guide for those responsible for creating Dive Procedures and Job Hazard Analysis (JHA). It consists of three sections:

- A checklist for planning and execution when diving in areas with potential for Delta-P.
- A list of relevant terminology useful in the discussion of Delta-P
- A list of resources for planning Delta-P diving operations.

The unclogging of drains is specifically not covered. Such operations require situationally specific barriers and controls and should be undertaken only with thoroughly engineered plans and as a last resort.

This checklist should not be considered an all-encompassing source for those planning Delta-P diving operations. It is intended to raise a level of awareness of Delta-P hazards at power-generating facilities and invite further research with the sources provided.

<u>NOTE:</u> No responsibility is assumed by the task force members involved in the writing of this document for any injury and/or damage to persons or property as a matter of liability, negligence or otherwise, or from any use or operation of any methods, product, instruction, standards, rules or ideas contained herein. No suggested test or procedure should be carried out unless, in the reader's judgment, its risk is justified, and the reader assumes all responsibility.

## 5.43 Delta P Diving Checklist

| Plan the Dive | Initials | Date |
|---|---|---|
| 1. The diving contractor must plan the scope of work considering Delta-P hazards. Consider alternatives to diving and use remote sensing methods when possible (i.e., remotely operated vehicle (ROV) or sonar imaging methods). Use findings to evaluate conditions and reduce divers' exposure to Delta-P hazards when possible. | | |
| 2. Ensure that all facility personnel are informed of the exact date and time ranges of diving operations. | | |
| 3. Identify, by position and name, the designated facility person (with sufficient technical and supervisory authority) for normal and emergency contacts. Ensure that a facility person with direct authority is onsite at all times. | | |
| 4. Write a dive plan based on the scope of work and Job Hazard Analysis *(JHA)*. The dive plan must include a prioritized mitigation plan specific for each *Delta-P* hazard, an emergency action plan, and an *umbilical management* plan. | | |
| a. Mitigation Plan | | |
| i. Review plans, blueprints, photos, surveys, and/or as-built drawings with the appropriate plant competent people to understand the layout, geometry, and operation of the facility or structure. | | |
| ii. With plant representative, locate and document all Delta-P hazards. Some examples include pumps, including ones that run intermittently such as fire pumps; flow control openings such as sluice gates, stop logs and valves; bar screens or traveling water screens; dams; locks; water tanks; cofferdams; pipeline penetrations; etc. | | |
| iii. Calculate the *capture zone* of the known hazards and specify minimum safe distance to be maintained from those areas by the diver and the diver's umbilical (see references 1, 3, 4, 5, and 6 for calculation methods). | | |
| iv. Plan the work for when the maximum number of *Delta-P* sources can be eliminated (i.e., pumps secured, valves isolated, etc.). Note: If a plant suggests that a pump or intake cannot be secured, require a written plan for plant procedures if an umbilical or diver becomes entangled in the pump. | | |
| v. Develop a site-specific Lockout-Tagout (LOTO) plan with the diving contractor and all concerned parties. Address items such as: personal locks where applicable, physical verification where possible, and setting of plant clearance boundaries. | | |
| vi. Determine Confined Space applicability and hazard *control* measures including permit required confined space entry protocols as required for topside personnel. | | |
| vii. Develop a plan to install physical *barriers* if possible. | | |
| viii. Develop a method to verify no-flow conditions, such as: use of *tell-tales*, flowmeters, an ROV), *sonar imaging*, observation of downstream water flow, etc. | | |
| b. Emergency Response Plan | | |
| i. Create an emergency response communication tree and process to inform facility personnel as well as on-site and off-site emergency personnel in the event of an incident. | | |
| ii. Identify available first aid and basic life support personnel for emergency operations. | | |
| iii. List facility and support personnel actions in the event of an emergency situation. (Key actions per team member role.) | | |
| iv. Outline emergency stop procedures for operations and equipment required for water extractions if feasible. | | |
| v. Identify worst-case recovery actions and personnel required. | | |
| vi. Define rescue/recovery assets that may be needed. | | |

| Pre-Dive | Initials | Date |
|---|---|---|
| 1. Conduct a pre-dive briefing with the dive team, plant personnel and any other stakeholders. Outline Go / No-Go criteria for the dive operation. | | |
| 2. With plant representatives, verify the mitigation plan for each Delta-P hazard. | | |
| a. Verify *capture zone* calculations and minimum safe distances with plant engineers. | | |

| | | |
|---|---|---|
| b. Verify the work is being conducted when the maximum number of *Delta-P* sources can be eliminated (i.e., pumps secured, valves isolated, etc.) as planned. | | |
| c. Execute hazardous energy work boundary processes, such as Lockout-Tagout or clearances. | | |
| d. Execute permit required confined space entry protocols as planned for topside personnel. | | |
| e. Diving contractor prepare physical barriers if applicable. | | |
| f. Diving contractor verify no-flow conditions through use of: tell-tales, flowmeters, an ROV, sonar imaging, observation of downstream water flow, or etc. | | |
| 3. When possible, the diving contractor will use sonar imaging methods to locate possible unknown DP hazards and inspect the areas prior to diving. Note: If any additional and/or new risks are identified then update the applicable sections of the dive safety plan and integrate into the pre-dive training briefing. | | |
| 4. The diving contractor will conduct *Just-in-Time* topside dry training / mock dive to include: the actual work procedure, the *umbilical management* plan, *three-way communication*, emergency response actions, and each member's role. | | |
| 5. Ensure *domain awareness*. All dive team members must understand the physical form of the structure, how the plant systems work together and where the *DP* hazards are including the *capture zones*. | | |
| 6. Test communications between the dive station and plant operations and EMS. | | |
| 7. Conduct and Emergency Response Plan briefing prior to initiating dive operations. | | |
| 8. The diving contractor will ensure the umbilicals are secured. | | |

| **Dive Operations** | **Initials** | **Date** |
|---|---|---|
| 1. Slowly deploy the diver down a ladder or via a stage. The diver must be extremely aware his/her domain. Report all water movement at the water entry point to the supervisor. | | |
| 2. Divers will continuously communicate all movements using *three-way communication* with topside and be tracked by monitoring umbilical length and communication with the diver and/or using *sonar imaging*. | | |
| 3. Continuously tend all divers and *fish the diver*. Avoid slack in diver's umbilical. Diver will verbally ask for slack (or ask for slack to be taken up) using *three-way communication*. | | |
| 4. Implement measures to ensure diver is unable to reach the *Delta-P* hazards. This can be done by flagging or tying of the umbilical topside, or installing physical *barriers* as applicable. | | |
| 5. When the work site is reached, the diver will report the water flow to the supervisor. Report any change immediately. If conditions are not as planned or change during the dive, bring the diver to the surface and reevaluate the plan. | | |
| 6. Begin the work only after the work area is deemed safe by the diver and diving supervisor. | | |
| 7. Supervisor ensures that dive team maintains situational awareness throughout the diving evolution. | | |

| **Post-Dive** | **Initials** | **Date** |
|---|---|---|
| 1. The diving contractor will modify the dive plan, work area map, and *JHA* to reflect lessons learned. | | |
| 2. The diving contractor will archive all plans, maps and *JHA's* for future reference. | | |

## 5.44 RELEVANT TERMINOLOGY

Barrier: Any physical control used to prevent the diver, diver's umbilical, or equipment from being entrapped by differential pressure.

Capture zone: The immediate area surrounding a differential pressure source that a diver or a diver's umbilical would not be able to escape. Sometimes referred to as an exclusion zone or danger zone.

Control: Any action taken to mitigate hazards to the diver.

Differential Pressure: Delta-P, or DP: The difference in pressure between any two points in an open or closed system which can result in fluid flow creating a hazard for a diver.

**Domain Awareness:** Understanding how domains operate and interact within their environment and how they could impact safety.

**Fish the diver:** Holding the diver's slack tight enough to feel him without restraining his movements. The tender should feel his movements in his fingers. This ensures the minimal amount of slack is always in the water limiting the possibility of it drifting into a DP Source or becoming entangled.

**Go / No-Go:** Criteria identified by both the dive team and the plant facility which is used to determine if a dive is conducted or not.

**JHA:** Job Hazard Analysis. An analysis of the hazards and risk associated which focus on identifying and controlling hazards.

**Just-in-Time**: Training conducted on the site to cover important site safety aspects just prior to the start of the job.

**Sonar imaging:** Sound returns sent through the water are measured and plotted to image underwater conditions. Various systems exist with a wide range of names. Site specific conditions will usually determine the best systems to provide the most reliable and clear images of conditions required.

**Situational Awareness:** Each worker must be aware of what is happening around them in terms of where they are, where they are supposed to be, and where anyone or anything around them is a threat to their safety.

**Tell-tale:** A device or object that automatically gives a visual indication of the state or presence of differential pressure. String mop head, lines, or ribbons on poles are examples of diver-held tell-tales.

**Three-Way Communication:** The sender (worker) states the message, the receiver (another worker) acknowledges the sender and repeats the message in a paraphrased form, and the sender acknowledges the receiver's reply is correct. Sometimes called three-part or repeat back communication.

Umbilical management: Procedures or physical controls to limit the umbilical and diver to areas free of differential pressure sources.

## 5.45 REFERENCES


- Association of Diving Contractors International (ADCI) – International Consensus Standards for Commercial Diving and Underwater Operations – 6.4 Edition. https://www.adc-int.org/files/ADCI%20Consensus%20Standards%206_4%20%202_23.pdf
- Association of Diving Contractors International (ADCI) video. The Dangers of Delta-P. https://videos.adc-int.org/dangers-of- • delta-p
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- OSHA Hazard Alert – Keeping Workers Alive During Commercial Diving Operations – OSHA Publication 4141-09 2021.https://www.osha.gov/sites/default/files/publications/OSHA4141.pdf
- OSHA Directive – CPL 02-00-151, 29 CFR Part 1910, Subpart T – Commercial Diving Operations, June 13, 2011. https://www.osha. gov/sites/default/files/enforcement/directives/CPL_02-00-151.pdf

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.*

## SECTION 6.0

# LIFE-SUPPORT EQUIPMENT: REQUIREMENTS, MAINTENANCE AND TESTING

Association of Diving Contractors International, Inc.

# 6.0 LIFE-SUPPORT EQUIPMENT: REQUIREMENTS, MAINTENANCE AND TESTING

## 6.1 GENERAL

Equipment such as helmets, masks, bailout systems, regulators, etc., that provide direct life support shall be of a type familiar to the diver and subject to a planned maintenance system.

Due to the life-support nature of diving, personnel involved in the operation, maintenance and repair of diving systems and equipment shall have appropriate training and experience in the maintenance and use of type of equipment used.

The diving supervisor shall ensure that all diving systems and equipment have been examined and tested prior to diving to determine their condition and suitability for service. No diving operation shall be permitted to commence until all systems and equipment have been thoroughly tested for proper functionality.

All relief valves related to life support systems shall be inspected and tested annually as to cracking pressure (must not exceed + 10% of MAWP.)

All fittings related to the life support system:

1. Shall be of corrosion-resistant material.
2. Have a minimum pressure rating of 200 psi or greater in accordance with the actual maximum allowable working pressure (MAWP) of the system of which they are installed.

At the dive location (vessel or land based) there must be a list of all life-support, and rigging equipment, with all applicable certifications documenting fitness for use. Maintenance and test records and documentation outlining design limitations and manufacturers' restrictions on use should be easily accessible at the company level and provided as needed. This may also include technical manuals, spares inventory for the equipment on site, documentation of planned maintenance, repair and maintenance records, equipment logbooks, and checklists.

Additionally, maintenance should be based on the amount of time the equipment has been in operation, manufacturer's recommendations, or the equipment's documented history and pedigree.

Maintenance schedules must be outlined and documented, with only qualified personnel performing the inspection, maintenance, and testing of equipment and systems. This documentation should be accessible at the company facility and provided as needed.

Fixed surface and saturation systems, at a minimum, will have to adhere to the above requirements.

## 6.2 MAINTENANCE RECORDS

Suitable equipment logs shall be established and maintained in a correct and current condition.

Life-support equipment shall have a unique identity assigned by the manufacturer or contractor, be easily visible, permanently affixed and traceable to the equipment/maintenance log.

Entries made in the equipment log shall describe the nature of the work performed, including the dates of modification, repair or test; the name of the individual performing the work or test; and the particular piece of equipment involved.

A preventive maintenance program is required for all life-support equipment.

## 6.3 DIVER'S DRESS

### 6.3.1 GENERAL

Diver's dress shall be suitable for the job intended and consider such factors as biological, radiological, chemical and thermal conditions.

### 6.3.2 DRY SUITS

**Diving personnel should be familiar with dry suit use requirements or should receive training prior to dry suit operations.**

Dry suits shall:

1. Have a means of preventing over–inflation, which could result in an uncontrolled ascent.
2. Be constructed of material suitable to the environment in which it is to be used.
3. Protect the diver from the environment, e.g., temperature or hazardous material.

### 6.3.3 HOT WATER SUITS

Hot water suits shall:

1. Flow sufficient water to maintain the diver(s) in thermal balance at the desired temperature.
2. Be capable of withstanding an operating temperature of 110º F (44º C).
3. Have a means to allow the diver to bypass incoming water prior to it entering the suit.

### 6.3.4 HARNESSES

A working diver shall be equipped with a full body diving harness that:

a. Is designed to:
   I. Provide a method to securely attach the umbilical to the diver.
   II. Lift an unconscious or injured diver and his or her equipment from the water in an emergency.
   III. Be utilized for underwater use.
b. Has an overall breaking strength of no less than 2,000 pounds.
c. Is equipped with a positive buckling device (i.e., designed to prevent strap pull-through and accidental release by the diver). It shall not be possible to release the harness by a single action.
d. Is equipped with at least one attachment point for the umbilical that is rated to at least the same breaking strength as the lifeline or strength member in the umbilical bundle. If the harness has multiple attachment points of different strengths, those suitable for umbilical attachments are to be clearly identified.
e. Is equipped with adjustable, permanently attached leg straps.
f. Is fitted with at least one lifting (recovery) ring, accessible when the diver is fully dressed, suitable for recovery of the diver from the water in an emergency using a hoisting device or other suitable means.
g. Is designed to maintain the diver in a heads-up position during recovery (using the lift ring/rings) from the water in an emergency.
h. Allows for easy disconnect of the main umbilical and weights, without removal of the main bail-out harness. This may be achieved by use of a separate/independent outer harness or jacket for the bailout system and diver's weights, or similar systems.
i. Is to be visually inspected prior to use for any signs of deterioration or damage. Any harness whose material condition is in doubt shall not be used until a determination is made by the diving supervisor.
j. Is to be regularly maintained in accordance with the manufacturer's recommendations.
k. Is certified by the manufacturer as detailed below.

- **<u>Certification and Testing of Diving Harnesses</u>**

A new diving harness shall be certified by the manufacturer or supplier to confirm that:

a. Each securing point intended for lifting a diver out of the water in an emergency shall withstand a tensile of at least 2,000 pounds for five minutes without sustaining damage that would render it inoperable or unsafe to use.
b. Each complete full-body harness, including adjustment systems, buckles, etc., shall withstand a tensile load of at least 2,000 pounds for five minutes, applied in the direction of lift, without sustaining damage that would render it inoperable or unsafe to use.
c. Each harness is clearly marked in a durable manner with the following minimum information:
   - Manufacturer's name.
   - Unique identifier.
   - Breaking strength.

### 6.3.5 WEIGHT BELTS

Weight belts shall:

a. Be of sufficient weight to maintain the diver at working depth.
b. Not be used as an attachment for the diving umbilical.
c. Be equipped with an appropriate release device.
d. Be attached to the diver in a manner to avoid accidental disengagement.

### 6.3.6 DIVER-WORN OR CARRIED EMERGENCY GAS SUPPLY

**Diver-worn or carried emergency gas supply (bailout) shall have a minimum calculated four-minute supply at the anticipated depth. (See bailout calculations in Section 11: Reference Materials).**

EGS systems shall:

1. Have a cylinder(s) meeting the requirements in Section 6.13.2
2. Have a depth-compensating regulator on the cylinder capable of delivering the proper pressure and flow to the diver's helmet or mask in accordance with the helmet or mask manufacturer's recommendations.
3. Have a means of attachment to the hat or mask, which prevents accidental disengagement.
4. The diver-carried EGS or mask/helmet shall have a positive means of isolating it from the primary gas supply.
5. When diving a gas mixture other than air, sample/test to verify contents.
6. Bottles must be clearly marked with content, date, pressure and the name of the individual performing this verification.

## 6.4 HELMETS AND MASKS

### 6.4.1 GENERAL

**Helmets and masks and their associated diver-carried regulators are components of a critical life-support system that, if not functioning properly, can expose the diver to significant hazards. As such, all helmets and masks and their associated diver-carried regulators shall be maintained and inspected in strict compliance with the manufacturer's recommendations. Suitable logs shall be maintained to reflect compliance.**

Helmets and masks used for surface supplied diving operations shall:

1. Be appropriate for the task intended.
2. Be fitted with a two-way audio communications system.
3. Be equipped with a non-return valve in the main gas supply that closes readily and positively.
4. Have non-return valves with springs not exceeding 3 psi cracking pressure.
5. Be made of corrosion-resistant materials.
6. Be maintained in accordance with manufacturer's specifications and have all modifications that affect safety or performance documented in the equipment log.

### 6.4.2 HEAVYWEIGHT DIVING HELMETS

Helmets designated as a heavyweight diving outfit (heavy gear) shall:

1. Meet the requirements of paragraph 6.4.1.
2. Have a helmet group consisting of a helmet, breastplate and associated valves and connections.
3. Be equipped with a quick-dump valve to prevent over-inflation.

### 6.4.3 LIGHTWEIGHT DIVING HELMETS

Lightweight diving helmets shall:

1. Meet the requirements of paragraph 6.4.1.
2. Be fitted to accept diver-worn EGS.
3. Be fitted to allow for positive and ready removal from the diver in all uses.

### 6.4.4 CLOSED-CIRCUIT AND GAS-RECLAIM-SYSTEM HELMETS

Closed-circuit and gas-reclaim helmets shall:

1. Meet general requirements of Section 6.4.1
2. Be fitted to function on open circuit.

### 6.4.5 BIBS (BUILT-IN BREATHING SYSTEMS)

Individual breathing equipment utilized in PVHO built-in breathing systems (BIBS) shall:

1. Be held in place by adjustable straps, hood or other suitable means that frees the diver's hands.
2. Be capable of providing 2.0 ACFM (56.6 alpm) at maximum depth. (Some regional and regulatory requirements may differ.)
3. Be equipped to allow user to adjust for ease of breathing or constant free flow.
4. Be equipped with an exhaust valve.
5. Be equipped to prevent over-pressurization or rapid negative pressure from endangering the user.
6. Be maintained in accordance with manufacturer's specifications.

## 6.5 HOSES

### 6.5.1 GENERAL (i.e. all hoses associated with the breathing gas system)

Flexible breathing gas hoses used with diving systems or equipment shall:

1. Have a minimum burst pressure equal to four times the maximum allowable working pressure (MAWP). Be suitable/rated by manufacturer for work intended.
2. Have a MAWP and flow rating not less than the system in which it is installed or used and be suitable for the service intended.
3. Have connectors with pressure capability equal to or greater than the designed working pressure of the system on which they are installed.
4. Have fittings of corrosion-resistant material that cannot be accidentally disengaged.
5. Be kink-resistant or arranged to prevent kinking.
6. Have a suitable temperature rating when used for hot water service.
7. Be visually examined and pressure tested after each pressure boundary repair. It is recommended that all hoses be flushed annually for the removal of any potential contaminents.
8. Be of suitable design to prevent collapse when used for operation with higher external pressure than internal pressure.
9. Have a maximum allowable working pressure equal to or greater than supply pressure plus 150 psi. (10.546 kg/sq).
10. Have all hose end fittings plugged, capped, or bagged (i.e. umbilical to helmet connection/bailout to helmet quick coupling connection). The use of tape by itself for this purpose is not permitted.

### 6.5.2 HOSES UTILIZED FOR BREATHING GAS (LP) (i.e. deck whips and all other LP hoses associated with the breathing gas system)

Breathing gas hose assemblies shall:

1. Meet requirements of paragraph 6.5.1.
2. Be suitable for breathing gas service.
3. Each hose assembly will be subjected to an annual pressure test to one-and one half times the design working pressure of the system. The test pressure should be maintained (when corrected for temperature) for 10 minutes.

### 6.5.3 UMBILICALS

Diver umbilical and dive hose assemblies shall:

1. Meet the requirements of paragraph 6.5.1 and 6.5.2.
2. Be marked from the diver/bell end in 10-foot intervals up to 100 feet and marked in 50-foot intervals thereafter.
3. Be subjected to an annual pressure test to one-and-one-half times the design working pressure of the system. The test pressure should be maintained without loss of pressure (when corrected for temperature) for 10 minutes.

**Note: To ensure uniformity throughout the commercial diving industry, ADCI Standard 006 recommends the following color coding be used by all participants.**

| | |
|---|---|
| 10 feet (3.05 meters) | 1 white band |
| 20 feet (6.10 meters) | 2 bands |
| 30 feet (9.15 meters) | 3 white bands |
| 40 feet (12.2 meters) | 4 white bands |
| 50 feet (15.25 meters) | 1 yellow band |
| 60 feet (18.29 meters) | 1 yellow band/1 white band |
| 70 feet (21.34 meters) | 1 yellow band/2 white bands |
| 80 feet (24.39 meters) | 1 yellow band/3 white bands |
| 90 feet (27.44 meters) | 1 yellow band/4 white bands |
| 100 feet (30.49 meters) | 1 red band |
| 150 feet (45.73 meters) | 1 red band/1 yellow band |
| 200 feet (60.98 meters) | 2 red bands |
| 250 feet (76.22 meters) | 2 red band/1 yellow band |
| 300 feet (91.46 meters) | 3 red bands |

Beyond 300 feet (91.46 meters), continue to place yellow bands after 50 feet (15.25 meters) and red bands after 100 feet (30.49 meters).

4. Be marked with a unique identity and be subjected to a planned maintenance program.
5. Consist of a breathing gas hose, communications cable, a means of determining the diver's depth, and a strength member (the strength member may be the entire hose assembly, if so designed).
6. Have a minimum break strength of the hose assembly, including terminating hardware (e.g., "D" ring or attaching points), of 1,000 pounds.
7. Pneumo hose shall be annually pressure-tested for leakage.

**The umbilical assembly used for the standby diver must be of sufficient length to reach the primary diver at his or her furthest possible excursion from the dive station.**

### 6.5.4 OXYGEN HOSES

1. Oxygen hoses shall meet the requirements of Section 6.5.2 and be suitable for use intended.
2. LP hose assemblies (less than 500 psi) used in systems containing greater than 50 percent oxygen are to be cleaned for oxygen service.
3. Hoses used for oxygen (over 50 percent) service shall be identified by a consistent color code or tagged "FOR OXYGEN USE ONLY."
4. Lubricants used to assemble fittings on hoses for oxygen service shall be compatible with oxygen.

### 6.5.5 BREATHING GAS HOSES (HP) (High pressure hoses associated with the breathing gas system)

**Breathing gas hose assemblies shall:**

1. Have a minimum burst pressure equal to four times the maximum allowable working pressure (MAWP) and be suitable/rated by the manufacturer for work intended.
2. Have connectors with pressure capability equal to or greater than the designed working pressure of the system on which they are installed.
3. Have fittings of corrosion-resistant material that cannot be accidently disengaged.
4. Be kink-resistant or arranged to prevent kinking.
5. Be visually examined and pressure tested after each boundary repair.
6. Be suitable for breathing gas service.
7. Each hose assembly will be subjected to an annual pressure test to the maximum allowable working pressure (MAWP) of the system. The test pressure should be maintained (when corrected for temperature) for 10 minutes.

# 6.6 COMPRESSOR SYSTEMS

## 6.6.1 COMPRESSORS AND GAS PUMPS

Compressors, boosters, gas transfer pumps and filters used to provide breathing air/gas for diving shall be designed and manufactured to:

1. Have suitable personnel protection around rotating machinery that meets applicable jurisdictional requirements.
2. Have the necessary instrumentation to facilitate operations.
3. Be of the proper type, pressure and flow rate, and be suitable for service intended.
4. Have its air intake arranged to be clear of exhaust fumes and other contaminants.
5. Have flexible pressure hoses in accordance with paragraph 6.5.1.
6. Have electrical controls, wiring and drive units meeting the jurisdictional requirements, when so equipped.

## 6.6.2 FILTRATION

Filters, when installed to prevent contamination, must meet or exceed the flow rate and pressure rating of the compressor or piping system in which they are installed and be able to deliver breathing gas in compliance with Compressed Gas Association (or equivalent) purity standards for extended operation.

## 6.6.3 TESTING

Compressors used for breathing gas shall be functionally tested per the following schedule, and shall conform to design specifications.

1. Prior to being put into service.
2. Periodically in accordance with manufacturer's recommendations and planned maintenance schedule.
3. During annual inspection.
4. After any repairs that may affect the compressor's performance.

## 6.6.4 AIR PURITY REQUIREMENTS

1. All compressors, transfer pumps or booster pumps used for breathing air service will be subjected to an air quality test every six months. Compressors with a discharge pressure of 500 psi or less shall meet the standards of the current ANSI CGA required for Grade D air, or equivalent. Compressors with a discharge pressure that exceeds 500 psi shall meet the requirements of the current ANSI CGA for Grade E air, or equivalent.
2. Air purity tests shall be taken at the discharge point that would normally supply the breathing gas system, the diver's hose or cylinder fill point.
3. Documentation of the latest test(s) shall be kept on file and available upon request.
4. Compressors used for breathing gas transfer other than atmospheric air shall be checked every six months to ensure they do not induce contaminants into the gas being processed.

# 6.7 MANIFOLDS

Manifolds:

1. Shall be plumbed for the proper pressure and flow to supply gas to the job as required.
2. All components shall be suitable for all gases being used, be of corrosion-resistant material, and have a pressure rating of 200 psi or greater in accordance with the actual maximum allowable working pressure (MAWP) of the system on which they are installed.
3. Shall be appropriately cleaned for the gas being used.
4. Shall not use fast-opening valves with oxygen service greater than 50% mix.
5. Shall be supplied with a system visible by the manifold operator at all times indicating the inlet pressure on each supply line and be equipped with a manifold supply pressure.
6. If the manifold is equipped with a pressure reduction regulator, each regulator installed in the manifold shall be equipped as stated in section 6.8. The regulator shall have an appropriate relief valve, with fast-acting shutoff valve (unless the breathing media has an oxygen mixture greater than 50% in which case a slow-opening valve shall be installed), downstream of the PRV to protect the lower part of the system. The PRV shall be set no higher than 10% of the MAWP of the system.
7. Shall have pneumo gauges rated at 1/2 of 1% accuracy or greater as needed for the job intended.
8. Shall have a back-up gas source available and connected to the manifold with an easy changeover capability.
9. Shall have fast-acting valves at all locations leaving the divers' breathing area (unless the breathing media has an oxygen mixture greater than 50%).

## 6.8 PRESSURE-REDUCING REGULATORS

Pressure-reducing regulators:

1. Shall be the appropriate pressure and flow required to do the job at the depth intended.
2. Shall be corrosion-resistant material.
3. Shall have an appropriate relief valve, with fast-acting shutoff valve (unless the breathing media has an oxygen mixture greater than 50%), in which case a slow-opening valve shall be installed), downstream of the PRV to protect the lower part of the system. The PRV shall be set no higher than +10% of the MAWP of the system.
4. Shall be equipped with inlet pressure gauges and outlet pressure gauges.

## 6.9 LAUNCH AND RECOVERY SYSTEMS (LARS)

### 6.9.1 GENERAL

Launch and recovery systems intended for the launch and recovery of a diver or divers between the surface dive location and the work location by either bell or stage shall:

1. Be designed, manufactured installed and tested in accordance with applicable design codes, standards and regulations.
2. Be fitted with two independent braking systems capable of holding 1.25 times the safe working load of the winch.
3. Be designed so that the load can be stopped, and held in position, if the power supply fails, is disengaged, is switched off, or if operating control is released.
4. Have controls located or equipped such as to afford the operator both a view and control of the lifting operation, or appropriate signalman.
5. After any installation, alteration, repair or failure, be thoroughly examined and be functionally and load tested to 1.25 times the safe working load of the handling system.
6. Have wire ropes and fittings that are:
    - Installed, terminated and maintained in accordance with design criteria and/or manufacturer's recommendations.
    - Visually inspected every six months for damage, deterioration or deformation.
    - Periodically examined and tested to recognized applicable codes and standards.
    - Have wire ropes and fittings that are rated eight times the load.
7. Have a spooling arrangement fitted if fleeting angle exceeds 2 degrees.

## 6.10 DIVER ENTRY AND EGRESS SYSTEMS

### 6.10.1 DIVING LADDER AND STAGE

Diving ladders and stages shall:

1. Be capable of supporting the weight of two divers plus their gear.
2. Be made of corrosion-resistant material or be maintained free of corrosion.
3. Be suitable for the purpose intended.
4. Ladders must extend a minimum of 3 feet below surface where installed.
5. Stages must be equipped with a safety chain and internal handholds for dive safety during launch and recovery.

### 6.10.2 OPEN-BOTTOM BELLS

Open-bottom bells shall:

1. Have an upper section that provides an envelope capable of maintaining a bubble of breathing mixture for a diver when the diver is standing on the lower section with his or her body through the open bottom and his or her head in the bubble.
2. Have lifting eyes rated for lifting 500 pounds for each occupant, plus the weight of the bell.
3. Be protected against and maintained free from injurious corrosion.
4. Able to accommodate two divers with gear in an uncramped position.

5. Be fitted with internal handholds for divers.
6. Have provisions for mounting of breathing gas cylinder(s) and regulator for emergency breathing at all depths of intended operation.

## 6.11 GAUGES

Gauges utilized with diving equipment or systems shall:

1. Be suitable for purpose intended.
2. Be cleaned for oxygen when installed in oxygen systems using mixtures greater than 50%.
3. When used to indicate a diver's depth:
   - Be of appropriate range and graduation.
   - Graduated in units consistent with the decompression tables to be utilized.
   - Calibrated to a known standard every six months.
   - Tested for accuracy in accordance with ASME B4-100-2005. Gauges must be tested at a minimum of 5 points, ascending and descending the full scale with a variance no greater than the accuracy of the gauge as stated by the gauge manufacturer. Test points must be spread over the full range of the gauge..
   - Be marked with a label, tag or sticker indicating date of last calibration, due date, and technician's initials, which will not interfere with full-scale visibility.
   - Have calibrations documented in the equipment log.
   - A pressure-limiting device may be fitted to avoid gauges being over-pressurized.
   - Be of appropriate range and graduation and rated at minimum .50% full scale accuracy for gauges 0-300 fsw or less and minimum .25% full scall accuracy for gauges greater than 0-300 fsw or greater as needed for the job intended.

     Examples:

     A. .50% accuracy of full scale:

     B. 0-300 fsw gauge would have+/- 1.5 fsw tolerance at any given test point.

     C. .25% accuracy of full scale:

     D. 0-300 fsw gauge would have+/- .75 fsw tolerance at any given test point.

     E. 0-1200 fsw gauge would have+/- 3.00 fsw tolerance at any given test point.
4. Master reference test gauge used for calibration should have an accuracy of at least 4X better than the accuracy of the gauge being tested. Master test gauge must be tested for accuracy annually if permanently installed. If not permanently installed, testing is required bi-annually.
5. Discrepancy- Be recalibrated when a discrepancy exists exceeding the accuracy of the gauge as stated by the manufacturer

## 6.12 TIMEKEEPING DEVICES

Devices utilized to monitor a diver's exposure time under pressure shall be suitable for purpose and easily readable.

## 6.13 COMPRESSED GAS EQUIPMENT

### 6.13.1 VOLUME TANKS/AIR RECEIVERS

Volume tanks used in diving systems shall:

1. Be designed, fabricated, inspected, tested and certified in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Section VIII, Div. I, "Unfired Pressure Vessels," and/or other statutory or classification society requirements.
2. Be equipped with a pressure gauge.
3. Be equipped with a check valve on the inlet side.
4. Be pressure-rated to the maximum system pressure on which it is installed.
5. Be equipped with a relief valve as required by code of manufacturer and tested at least annually.
6. Be equipped with condensate drain valve, located at its lowest point.
7. Be equipped with slow-opening valves when used with design pressures exceeding 500 psi.

8. Be cleaned for oxygen service and have slow-opening valves when used in systems containing greater than 50 percent oxygen.
9. Be inspected internally and externally at least annually for damage or corrosion. It is recommended that the volume tanks and air receivers be flushed annually for the rmoval of potential containments.
10. Be pneumatically tested to MAWP annually, utilizing the breathing mixture normally used.
11. Be hydro tested to 1.3 MAWP (ASME 2007 UG 99) every fifth year or after any repair, modification or alteration to the pressure boundary and marked with the test date.
12. Have a unique identity with results of all tests being recorded in the equipment log.

### 6.13.2 GAS STORAGE CYLINDERS AND TUBES

High-pressure gas cylinders or tubes shall:

1. Be manufactured to recognized code or standard.
2. Be equipped with an overpressure relief device.
3. Be visually examined externally at least annually for damage and corrosion.
4. If rack-mounted into banks of cylinders or tubes, have valves and regulators protected from damage caused by impact or from falling objects.
5. Be hydrostatically tested every fifth year to the requirements of the code of the manufacturer by an authorized test facility and stamped with the date of test.
6. Be inspected internally at least annually for damage or corrosion if used underwater by a qualified technician.
7. Be labeled as to contents. Fire-hazard warning signs should be erected in the vicinity of stored oxygen.
8. Be stored in a well-ventilated area, protected from overheating and secured from falling.
9. A record shall be kept in a designated place of the contents and pressure of each cylinder, quad or bank. These records should be updated daily when the system is in use.

### 6.13.3 SCUBA AND EGS (BAILOUT) BOTTLES

High pressure bottles used for scuba and EGS (bailout) shall:

1. Be manufactured to recognized codes or standards.
2. Be equipped with an overpressure relief device.
3. Be inspected internally and externally at least annually for damage or corrosion by a qualified technician.
4. Be hydrostatically tested every fifth year to the requirements of the code of the manufacturer by an authorized test facility and stamped with the date of test.
5. Have a unique identity with results of all tests being recorded in the equipment log.

**It is recommended that a maximum rate of 600 psig per minute be adhered to for the safe filling of EGS (bailout) bottles and that personnel refrain from over-pressurization or fast filling. Proper PPE should be worn by all personnel when charging cylinders.**

**Proper labeling of contents (bottom mix) should be visible on the bottle. It is further recommended that complete discharge of the bottom mix be conducted after the dive if the bottle is charged with a mixture other than air.**

## 6.14 PRESSURE VESSELS FOR HUMAN OCCUPANCY (PVHO)

### 6.14.1 GENERAL

Pressure vessels for human occupancy (PVHOs), associated with diving operations cover a wide range of applications, including, but not limited to, deck decompression chambers, diving bells, saturation living chambers, transfer locks and hyperbaric emergency evacuation systems.

PVHOs and associated systems are specialized equipment that are operated within the harsh environment of the diving industry and present potential risks to personnel supporting diving operations. PVHOs typically have unique attributes such as acrylic viewports and quick-opening pressure closures that have requirements for maintenance and safe operation.

The ADCI, in its technical and advisory capacity to the diving industry, has adopted a set of recommended standards for PVHOs specifically to minimize the risks involved with their safe operation. These standards were conceived as recommendations to be incorporated into industry practice. The standards cover PVHO design, fabrication, inspection, maintenance and repair. A PVHO is governed by industry standards, classification societies and national and applicable regulatory authorities (see "References" at the end of Section 6).

### 6.14.2 PVHO DESIGN AND CONSTRUCTION REQUIREMENTS

All PVHOs shall meet the following minimum requirements:

1. PVHOs and their associated systems shall be built in accordance with the most current version of ASME PVHO-1 and/or in conformance with the requirements of a classing society competent in PVHO diving systems.
2. Have a pressure relief device as per the most current version of ASME PVHO-1 or the code/standard of construction. Normally this is no more than 10 percent above MAWP (maximum allowable working pressure) of the PVHO.
3. Any doors, hatches or quick-acting closures associated with a TUP (transfer under pressure) system shall be equipped with an interlock system to prevent accidental opening under pressure. This would include medical locks, equipment locks and bell TUPquick closures.
4. Have a control panel with a dedicated pressure gauge indicating depth for each pressurized compartment. The gauges shall:
   - Be maintained with a calibration of each depth gauge within six months.
   - Be arranged so as to allow comparison with another gauge while in operation.

#### 6.14.2.1 Surface Diving Decompression Chambers

**When selecting a surface diving decompression chamber, careful consideration must be given to its MAWP capabilities relative to the planned deepest depth of the diving operation (See 7.).**

Surface diving decompression chambers shall:

1. Be dual-lock and multiplace (except emergency rescue chambers or chambers designed to mate with another P.V.H.O., if regulatory codes allow).
2. Have sufficient internal dimensions to accommodate a person lying in a horizontal position with another person attending (except designated diving bells, transfer locks and emergency rescue chambers).
3. Permit ingress and egress of personnel and equipment while the occupants remain pressurized.
4. Have a means of operating all installed man-way locking devices, except disabled shipping dogs, from both sides of a closed hatch.
5. Have illumination of the interior sufficient to allow operation of any controls and allow for visual observation, diagnosis and/or medical treatment.
6. Have viewports that allow the interior to be observed from the exterior.
7. Have a minimum pressure capability of 6 ATA (165 fsw [50 msw]; **and a minimum pressure capability of the maximum depth of the dive plus 1 ATA.**
8. Be capable of a minimum pressurization rate of 60 fsw (18.3 msw) within 1 minute. The inner lock may be blown down in advance to achieve this pressurization rate. There must be adequate air capacity on site to achieve deeper treatment depths.
9. Be capable of a decompression rate of 30 fsw (9.2 msw) per minute to 33 fsw [10.06 msw].
10. Have a means to maintain an atmosphere below a level of 25 percent oxygen by volume.
11. Have a means of maintaining an atmosphere not to exceed 1 percent surface equivalent carbon dioxide by volume.
12. Have mufflers/silencers on blowdown and exhaust outlets.
13. Have suction guards on exhaust line openings inside each compartment.
14. Have piping arranged to ensure adequate circulation.
15. Have all installed flexible hoses meet the requirements of Section 6.5: Hoses.
16. Have all penetrations clearly marked as to service.

17. Have piping in accordance with ANSI B31.1 and/or the most current version of ASME PVHO-1 or the classification society to which it was built.
18. Have the relief valve pressure settings tested annually and the test recorded in equipment log.
19. Pressure test the chamber and associated piping annually to MAWP, as stamped on the chamber name plate, and record in the equipment log.
20. Have an installed breathing system with a minimum of one mask per occupant per lock, plus one spare mask assembly per lock.
21. Have the capability to supply breathing mixtures at the maximum rate required by each occupant doing heavy work.
22. Have a non-return valve or quick disconnect with built-in check valve on through-hull penetrators supplying any built-in breathing system [BIBS].
23. Have a primary and secondary two-way voice communication system between the occupants and the operator.
24. Be equipped with a readily available means for extinguishing fire.
25. When fitted, have electrical systems designed and installed fit for purpose for the environment in which they will operate.
26. Chamber and BIBS exhaust should not vent into an enclosed space.
27. The chamber and its general area and controls should be adequately illuminated for operations at night. An enclosed space can mean a small shack, tented area, container, or inside of a vessel.
28. If external lights are used to illuminate the chamber internally, they shall not be placed in a manner to subject viewports to heat buildup and damage.
29. If the chamber is located away from the dive control station, there must be a means of communications between the two locations.
30. All chambers shall have an emergency breathing media immediately available to the BIBS in addition to the treatment gas.

### 6.14.2.2 Saturation Chambers

Saturation PVHO chambers, regardless of use; living chambers; TUP chambers; or any man-rated components of a saturation complex designed and intended for a human to be housed in shall have all the requirements of decompression chambers plus the following:

1. Have sufficient internal dimensions to accommodate the PVHO-rated occupancy of each person standing and lying on their assigned bunk in a horizontal position and personal storage.
2. The ability to analyze the ambient environment, including temperature, humidity, oxygen and $CO_2$, on a continuous basis.
3. Oxygen and $CO_2$ analysis gas sampling shall be from dedicated equipment with visual and audio alarms to ensure a predetermined high or low level is brought to the attention of the sat control life-support technicians
4. Chambers shall have the ability to analyze the gas samples in the chambers from a low and high point in the chamber. (This ensures gas stratification is identified and monitored.)
5. Chambers shall have an environmental control system capable of maintaining a physiologically suitable temperature and humidity during normal operations.
6. Metabolic oxygen make-up shall be controlled in a manner that will maintain a constant desired level.
7. Medical or equipment locks shall be located in strategic locations to ensure the PVHO occupants have the ability to receive supplies, food, drink and miscellaneous needs during normal operation as well as during emergency operations.
8. In chambers designated as sanitary and shower areas, the toilet receptacle shall have a raised vented seat to ensure a seal cannot be created by the occupant sitting on the toilet seat.
9. The toilet assembly shall have a safety interconnect device that will not allow the flushing of the toilet while the occupant is seated.

### 6.14.2.3 Diving Bells, Submersible Decompression Chambers, Closed Bells

Submersible decompression chambers/diving bells shall:

1. Meet the PVHO design and construction requirements where applicable.
2. Have sufficient internal dimension to accommodate the intended number of divers and their equipment.
3. Have protection against mechanical damage to valve penetrators, sealing surfaces, onboard gas, etc.
4. Have view ports to allow occupants to observe their external surroundings, also sufficient to allow observation of the interior from the exterior.

5. Have protection against mechanical damage on all view ports.
6. Have all piping penetrations equipped with a shutoff valve on both sides of the pressure boundary.
7. Have all penetrations, valves, gauges and piping clearly marked as to service and operation. A diagram or photographic records of the bell valves (internal and external) should be available at the dive control station.
8. Have identified points for connection of emergency services.
9. Have all installed flexible hoses meet the requirements of paragraph 6.5: Hoses.
10. Be equipped with sufficient primary and emergency electrical power for 24 hours.
11. Have a means by which occupants may read internal depth pressure and external depth pressure at all times.
12. Have an installed oxygen analyzer readable by the occupants.
13. Have an internal method of analyzing $CO_2$. (Chemical tubes are acceptable.)
14. Have a means of removing $CO_2$.
15. Have a primary two-way communication system between the diving supervisor and all divers supported from the bell, including the bell occupants.
16. Have a secondary communication system connected to the dive control center. This may be a sound-powered telephone with growler signal devices.
17. Be equipped with a "through-the-water" emergency communication system.
18. Be equipped with an acoustical beacon (must have sufficient power to last a minimum of 24 hours).
19. Have internal electrical systems that are designed for the environment in which they will operate to minimize the risk of fire, electrical shock or galvanic action of the PVHO.
20. Have electrical penetrators designed and installed fit for purpose for the environment in which they will operate that are tested to a minimum of two times the design working pressure of the bell and capable of withstanding applied pressure in either direction.
21. Have a capability of recovering an injured diver from the water (block and tackle/boom vang).
22. Have identified, installed and tested a secondary lift point capable of supporting the submerged weight of the bell.
23. Have a means of maintaining a physiologically suitable temperature during normal operations.
24. Have a means of controlling hot water flow to a diver locked out of the bell.
25. Have gas piping designed and arranged so that a venting or flushing of the bell will not adversely affect the breathing gas supply of any divers supported from the bell.
26. Be equipped with one individual breathing device for each occupant capable of providing breathing gas from both a surface-supplied source and the onboard emergency gas (plus one spare mask assembly).
27. Have sufficient onboard gas to allow a diver to remain outside the bell for 30 minutes at the maximum depth rating of the bell, at a breathing rate of 1.5 cfm.
28. Have a gauge indicating the pressure in the onboard emergency gas cylinders, readable by the bell occupants.
29. Have metabolic oxygen onboard to support the number of occupants for a period of 24 hours at a consumption rate of at least 0.5 liters per minute, per occupant. Note: Mixed gas in sufficient quantity may be substituted.
30. Have an oxygen supply so arranged that oxygen flow into the bell is limited to a controlled rate or volume relative to the bell internal pressure.
31. Have a first aid kit in a clearly marked and suitable container.
32. Have a basic tool kit.
33. Have a water-resistant copy of emergency procedures.
34. Have umbilical that meets the requirements of Section 6.5: Hoses, and provides breathing gas; pressurization and exhaust; communications and power; hot water; and other required services. The bell standby diver's umbilical must be capable of quick release action by the bellman once he is out of the bell in an emergency. If the bell standby diver's umbilical is stored outside of the bell, it must be adequately stowed to avoid damage during launch and recovery of the bell. The end of the bell standby diver's umbilical must be arranged to allow the standby diver to attach his or her mask or helmet and test it before the main diver exits the bell.
35. When fitted, have ballast release mechanisms that are designed to prevent accidental release.
36. Be designed so that the diver can freely exit and re-enter the bell if it is resting on the seabed. This normally requires a standoff frame and/or clump weight.

37. If diving below 500 fsw (152 msw), there must be a means of heating the divers' inspired gas.
38. Have a copy of the emergency tap code available to the bell occupants and dive control station personnel. (Emergency tap codes should be posted on the outside of the bell.)
39. Have a copy of the emergency tap code attached outside the bell near a viewport.
40. There shall be a means and written procedure to evacuate divers under pressure during an emergency.
41. No dive shall be made that exceeds the depth rating of the saturation system.
42. Maximum system working pressure shall not exceed the lowest-rated maximum working pressure of any component.

### 6.14.3 EMERGENCY EVACUATION SYSTEMS (EES)

An EES is a dedicated PVHO that is designed for transport/evacuation of divers in saturation in an emergency situation. Any planned saturation diving operation shall require an EES.

There are two types of emergency evacuation systems:

1. A PVHO adapted and designated for use in an evacuation. **(Not to include the primary bell.)**
2. A dedicated rescue system where a pressure chamber is fitted into or forms a part of a purpose built lifeboat.

**Emergency evacuation systems shall:**

1. Meet the requirements of sections 6.12.2.1 and 6.12.2.2: Saturation Chambers, as applicable.
2. Be outfitted to accommodate the maximum number of divers who may be under pressure.
3. Be fitted with a locating device.
4. Have oxygen or mixed gas on board to support the number of occupants for a period of 72 hours at a metabolic oxygen consumption rate of .017 cfm/0.48 liters per minute, per occupant.
5. Have a primary and secondary means to remove carbon dioxide from the atmosphere (e.g., battery and lung powered), as well as a means to monitor $CO_2$ and $O_2$ levels ($PPO_2$ meters are recommended).
6. Have onboard batteries to meet the demand of the electrical load for 72 hours.
7. Have a suitable first aid kit clearly marked, in a suitable container, and accessible.
8. There must be a detailed written procedure for evacuation of the EES contained in emergency procedures.
9. The EES shall be connected to the saturation system and a reserve supply of gas shall be available to press the EES to the deepest storage depth of the system during all diving or decompression operations. This procedure should be detailed in the emergency procedures for evacuation (see number 8).
10. The EES shall be capable to transfer supply and equipment under pressure.
11. Contain appropriate warning signs. (Refer to IMO warning sign document in the IMO Code of Safety for Diving Systems a.536 (13))
12. Have the means to be recovered, towed and lifted.
13. Shall be tested for positive buoyancy to verify design, after any structural modifications or annually.

The HRC shall have a compatible life-support control system (LSCS)[3] available within 24 hours maximum of the HRC location and shall be stored in a different location than the saturation system. HRC LSCS shall, at a minimum:

- Have two-way communication.
- Have gas control panels.
- Have gas suitable for a maintaining depth.
- Have emergency gas for BIBS.
- Be able to monitor oxygen and $CO_2$
- Have a written copy of procedures in place to maintain the environment.

# 6.15 MAINTENANCE OF PRESSURE VESSELS FOR HUMAN OCCUPANCY ADDENDUM

## 6.15.1 INTRODUCTION

The ADCI, in its technical and advisory capacity to the diving industry, has adopted a set of guidelines for the repair and maintenance of PVHO equipment that it recommends be incorporated into industry practice.

The diving business is, by its nature, an industry that operates within a harsh environment. Consequently, the design, construction and maintenance of diving equipment and the associated operational procedures are governed by industry and national standards, as well as national and international regulations (Appendix A). PVHO tankage and its associated hardware and associated systems are specialized equipment, rules for which were conceived specifically to minimize the risk involved.

## 6.15.2 GENERAL PRECAUTIONS FOR ACRYLIC VIEWPORTS

These are general precautions for the cleaning, operational inspection, installation and maintenance of acrylic viewports used in pressure vessels for human occupancy. **For additional information, it is recommended that ASME PVHO-2 be referenced. This document covers design, inspection and maintenance for acrylic viewports.**

## 6.15.3 CLEANING

When cleaning is required, viewports should be carefully cleaned, and surfaces must not be scratched. An acceptable cleaning agent is mild soap and water.

**Do not use solvents of any type** (alcohol, acetone, etc.) for any purpose on the window, gaskets or O-rings.

**CAUTION:** Only hand-cleaning is allowed. The use of power-driven tools is not permitted.

After cleaning, inspect the window for blemishes such as cracks, chips, dings, scratches, crazing, blisters or discoloration. (Crazing is the development of a network of fine spiderweb-type cracks on the surface of the window; it can be caused by either stress or exposure to solvents.)

## 6.15.4 IN-SERVICE INSPECTION

Operational inspections should be conducted prior to each chamber pressurization. Visually inspect the accessible exterior, interior and bearing surfaces for the presence of blemishes in the form of crazing, cracks, scratches, blisters and discoloration. A common flashlight will assist in locating blemishes such as chips, cracks, or crazing and in determining the condition of bearing surfaces.

Blemishes on the low-pressure face can serve as initiators of cracks and subsequent failure in flat disk and conical frustum viewports. For diving bells and submersible diver lock-out compartment viewports, both faces should be considered low-pressure faces.

The depth of the blemish can be measured with a depth micrometer with a pointed rod (Brown and Sharpe, or equivalent or an optical comparator). Consideration should be given to the concentration of scratches, cracks or crazing occurring in the center of the viewing area, as this may be an indication of stress.

## 6.15.5 INSTALLATION

Viewports should be properly cleaned and carefully installed to ensure proper fit and safe operation. All viewport surfaces should be free of defects.

All metal contact surfaces must be smooth and clean. Surface should be free of all defects and foreign matter. An oxygen compatible lubricant, which is compatible with acrylic, should be used. Retaining bolts should also be cleaned, inspected and lubricated.

O-ring and gasket sealing surfaces must be completely free of any foreign material, such as cleaning agents and solvents, rust, sand, grit, paint chips, etc.

All paint that will come in contact with the viewport should be fully cured.

## 6.15.6 MARKINGS

Viewport identification markings must be preserved on each viewport during cleaning and handling. Corresponding viewport documentation should be maintained with the PVHO documentation package.

**NOTE: Further information can be found in ANSI ASME/PVHO-1, Section 2.**

## 6.16 DAMAGE BY ACCIDENT

Major structural damage may be caused by an accident or mishandling. This may include things like:

### 6.16.1 PRESSURE HULL DAMAGE

- Dents.
- Gouges.
- Damaged penetrator (stripped threads).
- Mating flange.
- Lift lug or tie-down eye (bent, broken or hole elongation).
- Support base (frame deformation).

### 6.16.2 DOORS

- Damaged sealing surface.
- Bent/broken hinge.
- Damaged dogging mechanism.

### 6.16.3 VIEWPORT DAMAGE

- Crazing.
- Cracked/chipped.
- Weld spatter.
- Paint thinner damage.
- Overheated/blistered (permanent deformation).

## 6.17 DAMAGE BY CORROSION

### 6.17.1 GENERAL

More important than damage done by an accident, and often unseen until more extensive, is the damage done by corrosion. Most damage by corrosion can be avoided with a diligent preventative maintenance program, however, even with the best preventative maintenance programs, damage can still occur.

### 6.17.2 TYPICAL CORROSION DAMAGE MAY INCLUDE

- Pit corrosion (shell and heads).
- Crevice corrosion.
- Penetrators.
- Viewport sealing surfaces.
- Door faces.
- Sealing surfaces.
- O-ring grooves.
- Support legs/saddles.

### 6.17.3 CORROSION ALLOWANCE

Pressure vessels are typically built with a corrosion allowance in the calculated required metal thickness. This information is usually found on the pressure vessel certificate. Examination of corrosion-affected areas should be done in a manner necessary to determine if the corrosion has gone beyond the calculated allowable amount and may require remedial action.

## 6.18 REPAIR OF A PVHO

The owner should be aware of the requirements of the regulatory authority and of interested third parties, as their requirements will have a direct bearing on the repair specification.

PVHO repair must be approached properly, regardless of how well the work is done or the quality of the material used. Without a conscious effort to comply with existing rules and regulations, it is possible to have an expensive repair that does not meet the requirements and is unacceptable.

It is important that a defined method is used when approaching the repair of a PVHO.

Recommended steps for approaching any repair are as follows:

- Appraisal.

- Plan.
- Execution.
- Documentation.

## 6.19 APPRAISAL

1. The initial step is to appraise the damage. This means more than a casual look at the vessel and agreeing that it has been damaged. All damage should be investigated to determine the cause and what measures can be taken to prevent a reoccurrence.
2. Measure or otherwise quantify the damage so you can answer questions about the extent of the visible damage. Be aware that there may be areas of hidden damage. Make a sketch or map of the damaged area; photos may be helpful. Make a written report, describing the nature and extent of the damage. Be accurate, and include as much detail as possible. Be honest in your appraisal; remember that the goal is to save the PVHO vessel and to put it safely back into service.
3. Damage to the pressure boundary of the vessel will require that any repairs be done in accordance with the code of manufacture. Likewise, damage to the attached piping shall be repaired to the code to which it was built. Only components meeting the applicable code requirements should be used for repairs or replacements.
4. Gather all of the existing documentation on the vessel. This information will be needed by engineering, code repair shop, authorized code inspector, insurance adjuster, classing society surveyor, etc.
5. Depending on the type and extent of damage, it may be necessary to perform in a nondestructive examination (NDE) to determine the extent of damage. It may be necessary to grit-blast the vessel to bare metal to determine the exact scope of work.
6. Prepare a written report and budget for the repairs.

   **NOTE:** If the decision as to the disposition of the repair is yours to make, don't skip this step. It will become your tool to control the repair project.

## 6.20 PLAN

1. Make a technical plan for the repair. The plan should clearly establish the scope of work for the fabricator, as well as the scope of responsibility. This plan, if correctly drawn up, can function as the specification for the work and as part of a purchase order.
2. The plan should clearly state the codes, standards, rules, regulations and quality of workmanship that will govern the work. Don't forget the paperwork requirements. Be very specific about the paperwork and paper deliverables for which the fabricator or repair shop is responsible.
3. Prepare the drawings and/or calculations as necessary to affect the planned repair. An engineer, either in-house or outside, may need to be engaged to verify all details have been addressed.

   You should then obtain agreement from the regulator (jurisdiction) or classing society that:

   - The proposed repairs and techniques are within the code.
   - The proposed materials meet the code requirements.
   - The repair plan will be approved.

   Most repairs will require an initial survey to look at the vessel and assess your repair plan.

## 6.21 EXECUTION

1. Having obtained the concurrence of the required parties, and armed with your repair plan, budget, drawings and specifications, you are now ready to talk with a qualified fabricator or repair shop.
2. The least problematic choice is the original vessel fabricator. This is not always possible, but the likelihood is that the original fabricator will have the records that will make the repair and documentation go more smoothly.

   Unfortunately, many of the fabricators that have built PVHOs in the last 15 years are either out of business or may not have retained the records on your vessel. The ASME requires records to be retained for only five years. It is a good idea to require, as part of your purchase agreement with any fabricator or repair facility, that you receive a copy of all paperwork. If the vessel was registered with the National Board of Pressure Vessel Inspectors, you can get copies of the certificate by contacting the National Board.

3. The next best choice would be a fabricator that is currently building and certifying PVHO vessels. The fabricator should be authorized to apply the ASME "U" stamp and/or the "R" stamp from the National Board. The scope and criteria to differentiate between minor and major repairs is provided in the National Board Code ANSI- NB23. Alternatively, for PVHOs constructed to other codes, the repair shop should be certified to do repairs to the code to which the PVHO vessel was built.

## 6.22 TESTING

1. Prior to, during and after repairs, various types of testing may be employed. Test results should be retained as part of the equipment record.
2. All non-destructive examinations should be done in accordance with ASME Section-V: Non Destructive Examination, by personnel competent in the type of test employed.
3 Pressure tests should be done in accordance with a written procedure and appropriate safety precautions.

## 6.23 DOCUMENTATION

1. All repairs and alterations are to be recorded in the equipment log. This should be accompanied by references to certificates and identification markings. Pressure testing should likewise be documented and recorded in the log. Any alteration or modification should be reflected in all drawing revisions.
2. All certificates, drawings, calculations and reports should be retained for the service life of the equipment.

**A professional approach to the repair of PVHOs will yield professional results, thereby preserving a valuable asset and ensuring the safety of the occupants and operators.**

**It is impossible to guarantee that accidents will not happen. However, the probability can be significantly reduced by a good PREVENTATIVE MAINTENANCE PROGRAM and consistent safe practices.**

## 6.24 REFERENCES

- ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and 2
- ASME Section V : Non Destructive Examination
- ANSI — ASME/PVHO-1 and 2
- ANSI B31.1: Code for Pressure Piping, Power Piping
- Association of Diving Contractors International Consensus Standards for Commercial Diving Operations
- 29 CFR Part 1910: OSHA Rules for Commercial Diving
- 46 CFR Part 197: USCG Rules for Commercial Diving Operations
- IMO (International Maritime Organization) Code of Safety for Diving Systems, a.536 (13)
- IACS (International Association of Classing Societies)
    - ABS ( American Bureau of Shipping)
    - DNV ( Det Norske Veritas)
    - Lloyds Registry
    - National Board of Boiler & Pressure Vessel Inspectors ANSI-NB23

# SECTION 7.0

# EMERGENCY PROCEDURES, ASSESSMENTS AND REPORTING OF ACCIDENTS

Association of Diving Contractors International, Inc.

# 7.0 EMERGENCY PROCEDURES, ASSESSMENTS AND REPORTING OF ACCIDENTS

## 7.1 BASIC EMERGENCY PROCEDURES GUIDELINES

The following emergency procedures that may affect the health and safety of personnel are offered as minimum guidelines to assist companies in developing their own specific detailed emergency procedures. The steps that are listed may not be in order of preference. Each emergency will dictate its own priorities. In general, every emergency will cause the dive to be aborted until the cause has been fully remedied.

The pneumofathometer should always contain the same mixture as the diver breathing media. Emergency procedure drills should be performed on a periodic basis to ensure familiarity by the crews.

### 7.1.1 LOSS OF BREATHING MEDIA

1. Re-establish breathing media supply by:
   - Diver going on diver-worn or carried EGS (bailout);
   - Activating topside secondary breathing media supply; or
   - If applicable, put breathing media to diver's pneumo hose and confirm that the diver has bubbles, before insertion of the pneumo hose into the diver's neck dam.
2. Alert standby diver.
3. Diver goes to bell/stage/surface, as applicable.
4. If required, send standby diver to diver's assistance.
5. Terminate dive.

### 7.1.2 LOSS OF COMMUNICATIONS

1. Attempt to reestablish electronic communications.
2. If communication cannot be reestablished, attempt to communicate through line-pull signals.
3. If applicable, put breathing media to diver's pneumo.
4. Alert standby diver.
5. Diver proceeds to downline/bell stage or surface as applicable (if bell, attempt to use bell communications).
6. Bring diver to first stop once line-pull signals are established.
7. If required (unable to establish any form of communications with diver), send standby diver to diver's assistance prior to bringing diver to his or her first stop.
8. Terminate dive.

### 7.1.3 FOULED OR ENTRAPPED DIVER

1. Avoid panic and ensure diver does not ditch equipment.
2. Diver informs topside.
2. Alert standby diver.
4. Diver determines extent of entrapment.
5. Diver attempts to free himself or herself.
6. If required, send standby diver to diver's assistance.
7. When diver is free, if unable or unwilling to continue the dive, or if standby diver was required to go to diver's assistance, terminate dive.

### 7.1.4 INJURED DIVER IN WATER

1. Diver informs topside, and dive is aborted.
2. Alert standby diver.
3. Diver determines nature and extent of injury.
4. If required, send standby diver down to assist diver, administer first aid and evaluate injury. Standby diver should remain with injured diver.
5. Monitor diver's breathing. If diver stops breathing, overpressure his or her regulator, if possible.

6. If applicable, standby diver assists injured diver to surface, following proper decompression procedures, except when severity of injury indicates a greater risk than omitting decompression.
7. Institute planned diver recovery procedure.
8. Request required medical assistance and emergency evacuation, if required.

### 7.1.5 SEVERANCE OF DIVER'S UMBILICAL - GAS HOSE ONLY

1. Activate breathing media to diver's pneumo hose.
2. Diver activates bailout bottle.
3. Alert standby diver.
4. If required, diver inserts pneumo hose inside of helmet/mask after confirmation of bubbles to the pneumo hose.
5. Diver returns to bell/stage/surface.
6. If applicable, diver activates and uses emergency breathing media on bell/stage.
7. Terminate dive and follow proper decompression procedure.
8. If required, send standby diver down with additional bailout bottle or hose.

### 7.1.6 SEVERANCE OF COMPLETE UMBILICAL

1. Diver activates bailout bottle and returns to bell/stage/surface. If applicable, diver activates and uses emergency gas on bell/stage.
2. Alert standby diver.
3. Deploy standby diver if the diver has not immediately surfaced.
4. If applicable, deploy marker buoy at diver's last known location.
5. If applicable and available, standby diver provides new hose/bailout bottle. Otherwise, send standby diver down the downline or bell stage cable.
6. Terminate dive and follow proper decompression procedure.

### 7.1.7 FIRE

**Topside fire:**

1. Employ standard fire emergency procedures.
2. If required, suspend diving activities and evacuate diving station.

**Fire inside PVHO:**

1. Each chamber must have a means of extinguishing a fire in the interior.
2. Notify topside there is a fire in the chamber; evacuate to another chamber or lock if available or possible.
3. Divers inside the chamber should put on the BIBS with emergency gas.
4. Secure electrical power to non-essential systems.
5. Extinguish fire.
6. Vent the chamber.
7. Establish condition of the chamber occupants.

### 7.1.8 EQUIPMENT FAILURE - DIVER IN THE WATER

1. Evaluate effect on diver.
2. Inform diver of problem and action planned.
3. Alert standby diver.
4. Alert deck crew.
5. Diver informs topside of his or her readiness.
6. Activate plan and terminate dive.

### 7.1.9 ADVERSE ENVIRONMENTAL CONDITIONS

As a minimum, a JHA or specific procedure should be developed to address the following, as applicable:

- Adverse environmental conditions, including but not limited to:
  - Weather.
  - Sea state.
  - Currents.
  - Lightning.
  - Winds.
  - Methane/swamp gas.
  - Dangerous marine life.

### 7.1.10 OXYGEN TOXICITY IN WATER

1. Supervisor notes signs, or diver reports symptoms to topside.
2. Reduce oxygen partial pressure (switch to air), or lower PPO2 of mixed gasses.
3. Deploy standby diver.
4. Continue decompression on appropriate table unless a 50/50 nitrox mix is available for in-water decompression use.

### 7.1.11 OXYGEN TOXICITY DURING TREATMENT

1. Diver reports to topside.
2. Instruct diver to remove oxygen mask for 15 minutes. After all symptoms disappear, start oxygen again. Do not count time not on oxygen. Recommence decompression where oxygen stopped.
3. Tender shall be locked in.
4. If oxygen toxicity symptoms occur for the second time, repeat step 2.
5. If oxygen toxicity symptoms occur for the third time, discontinue oxygen and immediately request medical advice and assistance from designated point of contact.

### 7.1.12 EMERGENCY EVACUATION

1. Notify diver and all surrounding personnel of emergency and terminate dive.
2. Decompress diver according to proper decompression procedures. If not possible, follow omitted decompression procedures.
3. Evacuate all unnecessary personnel to safe platform.
4. Inform management of conditions as soon as possible.
5. Additional emergency procedures should be developed as needed, possibly including, but not limited to:
   - Loss of power supplies.
   - Loss of SDC (bell).
   - Loss of ROV.
   - Adverse environmental conditions.

## 7.2 ACCIDENT REPORTING

**Association of Diving Contractors International Requirements:**

**ADCI requires ALL General Member Companies and Associate Member Schools to report industry-related fatalities/catastrophic injuries.**

**Procedures:**

ADCI member companies can submit the reports on either their own company documents or the ADCI accident report form (See Section 7.2.1: Accident Report Form).

FOR U.S.-BASED COMPANIES:

**Federal Regulatory Requirements**

**46 CFR – Department of Transportation – Coast Guard**

Subchapter V-Marine Occupational Safety and Health Standards, Part § 197.484, requires the person in charge to notify the officer in charge, marine inspection, as soon as possible after a diving casualty occurs, if the casualty involves any of the following:

- Loss of life.
- Diving-related injury to any person causing incapacitation for more than 72 hours.
- Diving-related injury to any person requiring hospitalization for more than 24 hours.

Part §197.486 defines the form of the written report of casualty and requires:

- That the report be furnished on Form CG-2692 when the diving installation is on a vessel; or
- That a written report, in narrative form, be used when the diving installation is on a facility.

In either instance, the report must furnish the following information:

- Name and official number (if applicable) of the vessel or facility.
- Name of the owner or agent of the vessel or facility.
- Name of the person in charge.
- Name of the diving supervisor.
- Description of the casualty, including presumed cause.
- Nature and extent of the injury to persons.

**29 CFR – Department of Labor – Occupational Safety and Health Administration**

Subpart T – Commercial Diving Operations, §1910.440, requires that an employer record the occurrence of any diving-related injury or illness that requires any dive team member to be hospitalized for 24 hours or more, specifying the circumstances of the incident and the extent of any injuries or illnesses.

In May 1994, OSHA further clarified and defined the reporting requirement to state:

Employers are required to orally report any occupational fatality or catastrophe involving in-patient hospitalization of three or more workers within eight hours, per 29 CFR §1910.8. The report must include the following information:

- Company name.
- Location and time of incident.
- Number of fatalities or hospitalized employees.
- Contact person for the company.
- Phone number(s) for the company contact person.
- Brief description of the incident.

## EXEMPTIONS FROM FATALITY AND CATASTROPHIC ACCIDENT REPORTING DO NOT EXIST!

Even though most commercial diving companies are exempt from record-keeping requirements (SIC7389), all are required to:

- Orally report as defined above.
- Maintain a log of occupational injuries and illnesses.

ADCI member companies are urged to furnish ADCI with a copy of any report required by either 29 CFR or 46 CFR. In those instances, where the report is initially submitted in an oral format (29 CFR), furnish to ADCI information derived from log entries required by that regulation. Reports should be furnished to ADCI at the same time as submitted to regulatory authorities to ensure that ADCI is able to properly respond to enquiries regarding the actual circumstances rather than having to rely upon media releases that often are inaccurate or embellished.

It is NOT the intent of ADCI to disclose identities of companies, individuals or circumstances contained in reports received, unless these are commonly known as perhaps having been disclosed through a press release or safety notice by the company involved. The PURPOSE of the "system" is to gather information that can then be used in developing accurate statistical data, or where information received may warrant development of a safety notice or other guidance document intended to promote improved safety. The contents of reports may also be used to defend our industry from the actions of unscrupulous parties whose goals are clearly only those of defamation.

### 7.2.1 ACCIDENT REPORT FORM

## CASUALTY AND COMPLIANCE REPORT

**To:** **Association of Diving Contractors International**

Phillip.newsum@adc-int.org, 281-893-5118

**From:** ______________________________________________

(Company Name)

Subject: **CASUALTY AND COMPLIANCE REPORT**

---

Date of incident: ______ / ______ / _________

Location of incident: ______________________________________________

Description of event: ______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

Nature and extent of injury/injuries: ______________________________________________

______________________________________________

______________________________________________

______________________________________________

**COMPLIANCE QUESTIONNAIRE**

**What was the mode/method of diving on the date of the casualty?**

______________________________________________

**What was the manning level (number of dive team members) and assignments for the dive team?**

______________________________________________

______________________________________________

______________________________________________

**Was each dive-team member actively tended?**

______________________________________________

**What was the method of communication between the diver(s) and topside?**

______________________________________________

**Please detail the type and level of equipment used at the dive site (bailouts, manifold, compressors, umbilicals (hoses), harnesses, masks, helmets, etc. (Graphics or illustrations of the dive spread may be submitted in addition to the list.)**

______________________________________________

______________________________________________

______________________________________________

SECTION 8.0

# VESSELS AND FLOATING PLATFORMS FOR DIVING OPERATIONS

Association of Diving Contractors International, Inc.

# 8.0 VESSELS AND FLOATING PLATFORMS FOR DIVING OPERATIONS

## 8.1 GENERAL STATEMENT

A dive support vessel (DSV) is defined in this document as a floating platform used to support diving operations. Due to the very diverse and variable types of diving performed throughout the industry, DSVs vary accordingly, ranging from sectional pontoons and crane barges to purpose-built diving vessels with special four-point anchor systems or dynamically positioned vessels. From small craft for day-long projects to dynamically positioned vessels for offshore, long-term operations, DSVs must be carefully selected based on the requirements of the diving project, the diving to be performed, the tools and equipment required, and any potential environmental conditions.

While each diving platform will have its own characteristics that need to be assessed to enable the diving work to be carried out safely and successfully, certain common factors can be identified, and thus the particular "fitness for purpose" for a particular vessel, particular job and particular location can be determined. It is the responsibility of the diving contractor to select or reject the DSV based on the safety of the diving crew. While not all vessels are ideal, most can be adapted or modified, or additional equipment can be added to mitigate the shortcomings and therefore provide a safe working platform for the diving operation.

Much of the safety of the diver is based on the reliability of the diving life-support equipment; therefore, this equipment must be provided with adequate lashing, stowage and protection from the elements and other ongoing operations.

When selecting a DSV, great care must be taken to consider worst case for wind, tide, current and weather conditions. Adequate planning and proper equipment must be immediately available to allow the vessel to move from the dive site should environmental conditions require. While some vessels can withstand severe weather conditions, their ability to move out of the moor is limited to the ability of the anchor support vessel to bring the anchors in. Therefore, great care should be taken to not exceed these operational limits prior to getting the DSV out of harm's way.

- Generally, DSVs are commonly utilized to safely and efficiently provide:
- Transit to and from the work site for the personnel and equipment required.
- Position maintenance during diving operations with adequate accuracy and security.
- Deck space for the life support and safety equipment required.
- Deck space for the tooling required for the divers to perform the work.
- Communications for emergency and commercial purposes.
- Accommodation and messing facilities.

Additional services (encompassing medical facilities, communications, power supplies, craneage, life saving appliances, fire-fighting appliances, etc.).

Each diving contractor will examine the DSV for adequacy in each of the applicable categories above, assuring compliance with their company safety policies and those of the ADCI.

## 8.2 LIVEBOATING

Live Boating is a diving technique where a single surface-supplied diver performs work underwater while his hose is being tended from the bow of a vessel which is manually operated by the vessel master and underway using its main propulsion system.

## ADDITIONAL CONSIDERATIONS

Due to the inherent risks of liveboating operations, all other means of diving operations should be considered if possible. If liveboating has been determined to be the method of diving to be executed, these additional considerations should be taken into account to ensure safe operations:

- Performance of a thorough risk assessment
- Performance of drills for diver recovery, loss of breathing media to diver, and to test the vessel's emergency shutdown device
- Depending on the vessel, shaft rotation indicators, propeller guards, and other barriers to prevent the diver and standby diver's umbilical from coming into contact with the vessel propellers should be considered for utilization
- An assessment of work to be performed, water depth, and the communications available on the vessel should factor into the manning levels of the crew
- Ensure that the dive supervisor has a clear line of sight of the diver's umbilical entering the water and diver's bubbles
- Ensure that there are direct communications between the captain, diving supervisor, standby diver, and tender

### 8.2.1 MINIMUM REQUIREMENTS

**All equipment and manning levels should be considered the recommended minimum for approaching this diving application, based on one dive and any applicable decompression required. Increased manning levels and additional equipment may be required for any diving in excess of one dive and any decompression required. Proper pre-job planning should be conducted to ensure that the necessary levels of personnel and equipment are available for diving operations. The ADCI recommends that alternate methods other than liveboating are explored.**

**If a diving operation requires a hand-held tool that is separately tended from the diver, it is highly recommended that it be performed by methods other than liveboating. However, if the job can be performed only through liveboating, only one surface-powered tool can be used at a time. Small umbilicals, (e.g., CP probes and pipe trackers) should be married to the diver's umbilical.**

The following are minimum requirements for liveboating operations:

- **No liveboating operation may include planned in-water decompression.**
- **No liveboating operation shall be conducted on scuba.**
- **No liveboating shall be performed within another vessel or barge's anchor spread.**
- **The maximum depth for conducting live boating operations is 130 fsw (39.6 msw).**

1. Minimum Personnel

   In all cases, personnel and equipment shall be selected to ensure maximum safety during operations. On small boats/vessels of less than 33 feet (10.05 meters), it may be permissible for the crew to consist of no fewer than three persons (diving supervisor, diver and tender/diver) due to space limitations.

   a. Liveboating diving operations (0 – 130 fsw [39.6 msw]) (Vessels larger than 33 feet / 10.05 meters). The dive crew shall consist of a minimum of seven (7) diving qualified personnel.

   - One (1) Dive Supervisor
   - One (1) Diver
   - One (1) Standby Diver
   - Two (2) Tender/Divers
   - Two (2) personnel that are qualified divers to assist with rescue boat operations

### 8.2.2 DIVING SUPERVISOR

Must be experienced and knowledgeable in liveboating operations.

### 8.2.3 PROCEDURES

a. Continuous and easily understandable communications will be maintained between the dive station and wheelhouse at all times.

b. The vessel master is notified before the diver enters or exits the water and the propulsion system must be disengaged.

c. The boat will be maneuvered in such a manner so as to permit the tender/diver or diving supervisor to continuously monitor the direction of the diver's umbilical with respect to the dive control station.

d. The vessel's propulsion system should be stopped before the diver enters or exits the water.

e. Liveboating shall not be done:
   - In seas that impede the station-keeping ability of the vessel.
   - In other than daylight hours.
   - During periods of restricted visibility. (Restricted visibility means any condition in which vessel navigational visibility is restricted by fog, mist, falling snow, heavy rainstorms, sandstorms or any other similar causes.)
   - Any time existing conditions make liveboating unsafe in the opinion of the vessel captain and/or supervisor.

f. A standby diver will be continuously prepared to enter the water when directed by the diving supervisor.

g. All liveboating operations shall be tended from the bow, and the boat shall be operated from the wheelhouse or flying bridge.

### 8.2.4 MINIMUM EQUIPMENT

a. The vessel shall be acceptable to the diving company and the diving supervisor.

b. A "kill switch" shall be in the immediate vicinity of the operator of the boat for instantaneous shutdown of the engines.

c. For operations on dynamically positioned vessels (see **DP System Section 8.3).**

d. A diver-worn or carried emergency gas supply bottle shall be worn by the diver.

e. A mechanical device to prevent dive umbilical entanglement in the vessel's propulsion system.

f. During liveboating operations, a third diving hose connected to the manifold shall be available for emergency use except in the case of a vessel 33 feet/10.05 meters or less.

g. A boat ready to be launched with crew in the event of an emergency (for vessels larger than 33 feet/10.5 meters).

h. A method of clear communication between the tender/diver and dive supervisor.

i. For emergency purposes; a means must be available to provide a stable platform for the diver for in-water decompression for vessels over 33'.

### 8.2.5 VESSEL OPERATOR

The vessel operator must be experienced in liveboating operations and familiar with the scope of underwater tasks including depth and duration of dive.

## 8.3 DYNAMICALLY POSITIONED VESSELS

### 8.3.1 INTRODUCTION

These guidelines relate to and are intended to assist in the design and operation of dynamically positioned (DP) diving support vessels. Their purpose is to provide a basis from which designers, suppliers, builders, vessel owners, diving contractors, masters, diving supervisors, and charterers can develop the most suitable equipment and operating procedures for each vessel and to provide a yardstick against which the suitability of dynamically positioned vessels for diving operations can be assessed.

Implementation of the guidelines will vary from vessel to vessel, and the characteristics of each vessel will affect its suitability for particular operations. Even in the short term, this may alter in the light of changes in personnel and system components. It is therefore important that these guidelines be used not only by owners in preparing vessels (or diving operations), but also by potential charterers in assessing vessels suitable for their particular needs.

The general conduct of diving operations from DP vessels should follow the same principles as for other diving operations. In addition, no effort should be spared to establish DP operational reliability and ensure that the effects on the divers are minimized if the vessel does lose station. All those connected with the operation should keep this in mind at all times.

Owners/operators should implement an in-house DP competency assurance process for key DP personnel which is structured, systematic and progressive. It should be noted that DPO certification is only one element in the competency assurance process.

**In accordance with IMO, the ADCI requires, at a minimum, vessels to be DP2.**

### 8.3.2 PRINCIPLES

#### 8.3.2.1 Introduction

These guidelines are built around three main and interrelated principlesthat are simply stated in this section. The remaining sections contain guidance on their implementation. Though they cover many aspects of DP diving systems and operations, they are not definitive, and decisions about operations not covered should still be based on these main principles.

#### 8.3.2.2 Single-point Failures

A "catastrophic failure" is defined in these guidelines as a failure that would in itself cause risk to divers. In effect, this means that the failure would cause the vessel to move from its intended position. A fundamental principle of all DP diving vessel design and operation is that no single fault should cause a catastrophic failure. This principle immediately introduces the concept of redundancy. In doing so, it must be stressed that redundancy can be achieved in several ways (not merely by duplication).

#### 8.3.2.3 Capabilities and Limitations of DP Diving Systems

Any system can operate satisfactorily provided it is not subjected to conditions that are outside its operating capabilities. A fundamental principle of DP diving vessel operation is that the operating requirements of the system are never allowed to exceed the vessel's capabilities in any respect. This principle requires that the vessel's capabilities and limitations are clearly understood and updated with experience and that indications are provided when predetermined limits are being approached.

### 8.3.2.4 Personnel Capabilities

Any equipment or system can work as intended only if it is operated correctly. The more complicated the equipment or system, the greater the demands upon personnel operating it. A fundamental principle of DP diving vessel operation is that relevant personnel should be fully capable of performing the tasks entrusted to them. This requires them to have the necessary background and experience or to have received appropriate training and guidance.

## 8.3.3 DP SYSTEM

### 8.3.3.1 Introduction

Implementation of the first principle (single-point failures) involves correct system design. In the context of these guidelines, the DP system is defined as "all equipment and components involved in retaining the vessel in its required position." The principle states that "no single fault should cause a catastrophic failure." To ensure that a DP system adheres to this principle, a failure modes and effects analysis of the main components should always be carried out. Where such an analysis indicates that a single fault could lead to a catastrophic failure, the relevant component, sub-system or its operating procedures should be redesigned to avoid or take account of the effects of the single point of failure. In this section, some design considerations concerning the main components of DP systems are examined. Recommendations concerning condition monitoring are included based on the premise that to react correctly, system operators must be aware of the failure of any main components.

### 8.3.3.2 Thrust Units

**1. Configuration**

Thrust unit installations should be designed to minimize potential interference of wash with other thrust units, sensor systems, the diving system and the divers, and the effect of hull surfaces on thrust unit efficiency within the constraint of ship design.

**2. Redundancy**

Thrust units and, where appropriate, rudders, should be situated to achieve fore and aft, athwart ships, and rotational thrust must be configured so that the loss of any one thrust unit always leaves sufficient thrust in each direction to ensure that the vessel holds position and heading when operating within its forecast operational capability.

**3. Failure Mode**

In the event of pitch, azimuth, motor speed control malfunction, or when control error becomes unacceptable, the function controlled may remain the same as it was at the time of failure, the pitch may be automatically set to zero, or the thrust unit may be automatically stopped and deselected. Under no circumstances should thrust units assume maximum thrust condition on failure.

**4. Emergency Stop**

Means should be available whereby any thrust unit may be stopped from any DP control without using the DP computer to generate the command. The means provided should be adequately protected against inadvertent operation.

**5. Condition Monitoring**

The following list indicates the main functions that, where applicable, should be monitored either by permanent remote means or by local means at frequent intervals.

- Status (online/offline).
- Thruster motor stator winding temperature (high only).
- Thrust unit rpm/pitch ordered and indicated (with display or 80 percent thrust output).
- Oil pressure.
- Hydraulic power-pack status.
- Azimuth ordered and indicated.
- Thrust-bearing temperature.
- Power supply loss.
- Lube oil/hydraulic fluids — pressure/temperature/level.
- Response to command signal deviation.

**Note:** Monitoring of diesel engines, where used to drive thrusters by direct drive, should be in accordance with design parameters of the system.

### 8.3.3.3 Power System

**1. Power Factors**

Power system design should, so far as possible, provide for generators to be run at power factors that effectively match the characteristics of the load.

**2. Redundancy**

The power source system, whether individual diesels or central electricity generation plants, should be capable of producing sufficient power to meet the vessel's operational capability subsequent to the failure of any single power unit.

**3. Power Management**

Arrangements should be provided to ensure that when diving operations are being carried out, non-essential loads are shed in reverse order of importance before power consumption reaches maximum available supply. Power supplies to thrusters to maintain station, as well as to the diving system, should be safeguarded. Arrangements should also be made to ensure that sufficient power is always available to enable the vessel to retain position within a predetermined accuracy in prevailing and foreseeable conditions if any one on-line power unit fails. This may mean providing for running up and bringing online additional power units as power consumption increases.

**4. Essential Services**

Essential services such as fuel, oil, ventilation and generator cooling should also be designed to avoid system failures stemming from failures of critical components, e.g., filters, pumps, power supplies, etc.

**5. Operating Limits**

Power operating limits should be specified and alarmed for diesel engines, turbines, motors and generators to avoid engine damage and power factor problems.

**6. Distribution Network**

Power distribution systems should be such that no single failure can prevent distribution or sufficient power to thrusters to permit the operation of the vessel within its full operational limitations.

**7. Condition Monitoring**

The following list indicates the main functions that, if applicable, should be monitored either by permanent remote means or by routine local means at frequent intervals.

- Distribution Network
  - Circuit breaker status (auto connect/disconnect equipment).
  - Bus bar voltage.
  - User current levels.
  - Load-shedding trips (online and tripped).
  - Backup power supplies availability (emergency generator or accumulator batteries).
- Diesel Engines
  - RPM.
  - Oil pressure/temperature.
  - High main bearing temperature indication.
  - Auto-start equipment and sequence.
  - Bank and individual exhaust temperature.
  - Oil level.
  - On-line fuel tank level.
  - Fuel pressure.
  - Fuel rack setting (if applicable).
  - Clutch status (if applicable).
  - Jacket water pressure and temperature.
  - Salt water-cooling pressure.
  - Change air pressure (where applicable).

- Generator/Motors
  - Bearing lube oil flow and temperature.
  - Terminal voltage.
  - Current.
  - Stator winding temperature (high only).
  - Frequency (low)/speed.
  - Status (shutdown, standby, online).

### 8.3.3.4 DP Information Input Systems

**1. Position Sensor Redundancy**

It is recommended that at least three independent position sensors be available. These need not all work on different principles, but if similar systems are to be considered as independent, they should not be subject to common mode failures (e.g., no single factor should affect more than one system). Whenever DP diving operations are being carried out, at least three independent sensors should be deployed, connected to the DP computer(s), and in use. It is recommended that the third sensor, if not online, should be ready for immediate use as a backup. To aid the correct use of sensors in particular circumstances, manufacturers must provide information about the performance and operational limitations of any position reference sensors supplied for use by DP diving support vessels.

**2. Vertical Reference Units/Systems**

Two vertical reference units/vertical reference systems should be operating whenever DP diving operations are being carried out and position reference sensors requiring their input are in use. At least one of them should be online.

**3. Wind Sensors**

Care should be taken in the placement of thewind sensors to minimize the effect of turbulence from superstructures. The effect of helicopter downdraft, though normally limited, should be borne in mind. Two wind sensors should be installed in physically separated positions to take account of failures and false readings resulting from external factors. In some circumstances where interference is unavoidable, the inaccuracies caused by switching off wind sensors may be less than those caused by their false information.

**4. Heading Reference Sensors**

Two independent heading reference sensors (e.g., gyrocompass) should be running with either both online or one online and one available as immediate back up during DP diving operations. Automatic or manual selection of the on-line compass may be provided.

**5. Reliability**

Sensors should be designed and proven for continuous reliability in the exposed positions in which they operate.

**6. Condition Monitoring**

Monitoring of DP information input systems should include:

- Facilities for regular full-function checks.
- Alarms for transducer or circuitry failures.
- Detection of data deviation or corruption.
- Alarm for power supply loss.

**7. Position Data Processing**

Data from all position sensors should be automatically processed (not manually selected):

- To reject spurious data.
- To stabilize output in the event of failure.
- To select preferred data.
- To alarm if system develops bad geometry or signal loss occurs.
- To permit a smooth changeover between systems.
- To monitor the sensor status.

### 8.3.4 COMPUTER/CONTROL SYSTEM

**1. Purpose**

The primary purpose of the DP control system computer is to calculate and order the necessary thrust unit operations required to maintain a vessel in its chosen position. Though it is possible to use the computer for many ancillary functions (e.g., data processing and presentation, power management, etc.), care should be taken to ensure that these cannot prejudice its proper operation in its primary role.

**2. Control System Redundancy**

There should be at least one backup method of controlling the vessel's thrust units in order to retain position in the event of a failure of the online control system. A second automatic control system can best fulfill this role. If a second automatic system is not fitted, then a joystick control system would be an acceptable backup, provided:

- It affords manual control of fore and aft, athwartships and rotational thrust with automatic control of heading.
- The joystick control lever is situated in the DP control area and located in such a position that the operator has a clear view of the vessel and everything in its vicinity.
- The joystick control system and its power supply are independent of the failed automatic control unit, but provision is made to ensure smooth continuity of thrust unit operation on failure of the automatic control unit.
- Data from a gyrocompass are input directly to the joystick control system.
- A simple display of vessel position relative to its required position is provided independent of the failed unit, but with the means to ensure its correct alignment with the failed unit at the time of failure.
- It is used only to maintain position for short periods of time, e.g., to recover divers in an emergency. It is recommended that the automatic control system(s) incorporate a joystick facility to assist in maneuvering the vessel onto location.

**3. Power Supplies**

Provision should he made to ensure that power supplies to computer(s)/controller(s) are safeguarded at all times. This could involve provision of duplicated conversion machinery and a backup battery supply. Batteries should have sufficient capacity to maintain the necessary supplies for at least 30 minutes, and a warning of batteries not being fully charged should be provided.

**4. Services Redundancy**

Where possible, the design should ensure that services are duplicated and are so divided that if local ventilation and cooling fail, or fire or flooding occurs, sufficient services are retained to enable the divers to be recovered safely.

**5. DP Console Location**

The DP console should be situated so that the DP operator can observe DP controls, see outside the vessel and be aware of deck operations and the vessel's relationship to surface structures, etc.

**6. Monitoring Information**

Overall monitoring information should be displayed or made available for call-up in a manner that avoids information overload on the DP operator. Data should be displayed in the simplest manner for easy assimilation. The following information should be available to assist in monitoring overall DP performance:

- Thrust unit configuration and rpm or pitch levels ordered and indicated (with display of 80 percent thrust).
- Consumed online power as percentage of total of available (with special indications at 80 percent).
- Available thrust units on standby.
- Position sensor status and validity.
- DP system status and validity.
- Vessel's target and indicated position.
- Vessel's target and indicated heading.
- Alert-level status (manually operated).
- Limited history event recording system.

This should provide an automatic record of changes in the main parameters concerned with the vessel's performance, such as:

- Wind speed and direction.
- Position and heading errors.

- Position reference sensor availability and use.
- Thrust unit availability and use.
- Power unit availability and use.
- Computer availability and use.

## 8.3.5 COMMUNICATION SYSTEMS

**1. Internal Voice Communications**

As a minimum requirement, voice communications should be available to ensure the immediate and clear transfer of information between all responsible parties.

As a minimum requirement, direct communications should be provided between DP console and dive control; dive control bell and diver; dive control and life support control; dive control and bell handling control; dive control, DP console and ship's derrick or crane; DP console and master's cabin; dive control, DP console and senior diving supervisor's cabin; and DP console and engine (control) room.

All essential voice communications systems should be provided with 100 redundancy where practicable, either through duplication or provision of an alternative system. Terminals should be situated close to the normal operating positions of personnel for whom they are provided. Primary systems should provide clear voice reproduction and should not detract from users' abilities to perform their main functions.

**2. DP Alert System**

A system of lights shall be provided in the saturation control room, air or mixed-gas diving control area, working deck and, where applicable, the ROV or submersible control position manually activated from and repeated in the DP control room. The following lights should be used:

- Steady green light to indicate vessel under automatic DP control, normal operational status and confirming the alert system is functional.
- Flashing yellow light to indicate degraded DP operating alert.
- Flashing red light to indicate DP emergency.

A distinctive alarm should sound in the saturation control room, air or mixed-gas diving area, master's cabin, operations superintendent's cabin (if applicable), and senior diving supervisor's cabin in conjunction with the flashing red light. Provision of a means of cancelling the audio and flashing functions of the signals from the receiving positions when they have been noted should be made.

## 8.3.6 MAINTENANCE OF EQUIPMENT

Proper maintenance of equipment is essential to its correct performance. Clear instructions about the type and frequency of maintenance required by all components of DP systems should be compiled by vessel owners with the aid of manufacturers and suppliers. These should be issued to vessels together with a system to monitor their correct implementation.

## 8.3.7 CAPABILITIES AND LIMITATIONS

### 8.3.7.1. Introduction

The second principle (capabilities and limitations of DP diving systems), involves knowledge of a vessel's capabilities and the operating requirements. An awareness of the special limitations of diving from a DP vessel should be present at all times amongst those concerned with the operation. In addition, certain principles should be adopted to minimize the possibility and effects of the risks to divers due to uncontrolled vessel movements. Notwithstanding these principles, the authority of appropriate personnel to order the termination of DP diving operations, if they consider such operations hazardous even when conditions are within the guideline limits, should not be diminished.

### 8.3.7.2 Vessel's Operational Capability

The maximum continuous operational station-keeping capabilities for DP diving should be forecast for each DP diving support vessel. They should be expressed in terms of direction and magnitude of wind, associated wave drift force and current combinations. They should be defined as "those environmental conditions in which the vessel could maintain chosen position and heading to a satisfactory confidence level with any single-thrust or power unit failed and with power available for the foreseeable diving requirements and the vessel's essential services."

Capability plots or envelopes of these maximum tolerable environmental forces and their relative heading should be produced to assist in defining this information. These should include a statement of the position and heading tolerances, as well as the corresponding confidence levels associated with the capability plots. It should be clearly appreciated that they are only a guide to a vessel's position-keeping capabilities and an indication of those capabilities under certain conditions.

Capability plots should be based initially on vessel design information but should be modified in the light of practical experience. Care should be taken that such modifications are properly reviewed and authorized by the vessel's owner. Detailed explanations of the assumptions made in producing these plots should be provided. For example, the power consumption of the diving system and emergency domestic load, the definition of wind speed and thrust output, the assumed wave drift and current conditions, and details of the means to identify the position-keeping tolerance and corresponding confidence levels should be included.

It should be noted that the requirement to hold station and heading within operational limits with any single-thrust or power unit failed assumes a "worst case" failure. Therefore, in determining the operational limit "envelope," the chosen "worst case" thrust unit will probably vary depending on the relative direction of environmental forces. This should be taken into account.

When determining the vessel's position-holding capability, consideration should also be given to any interactions between thrust units, hull and relative water movement. To simplify the calculation/presentation task, it is proposed that the current force be based on a one-knot current running in the same direction as the chosen wind and wave forces and that the number of "directions" chosen for these coincident forces may be limited to 30û increments.

### 8.3.7.3 Degraded Operational Capability

The principle of ensuring that no single fault can cause a catastrophic failure allows the vessel to be operated with confidence within its designed operational limitations. If the operational capability is degraded, the operation of the vessel should reflect the new status. There is one principal source of degradation of operational capability, namely loss of redundancy of a subsystem.

### 8.3.7.4 Positioning Accuracy

The positioning accuracy of a DP vessel is subject to several sources of error that can act cumulatively. A forecast of the position and heading tolerances and the corresponding confidence levels should be included with capability plots and should be taken into account when planning operations close to other vessel installations. Excursions around the intended position, even if causing no worse problems, tend to swing the bell in a manner that, if it becomes excessive, may be dangerous. With surface-supplied air or mixed-gas diving operations, excessive excursions of the vessel could cause hazard to the diver. Reduction to the minimum achievable level should be a matter of priority both on setting up on DP and, if necessary, in the course of DP operations.

### 8.3.7.5 Operating Procedures

The objective of all operations should be to ensure that a vessel operates effectively and safely. To achieve this, using the design principles already stated, carefully prepared operating procedures should be adopted. These should themselves be based on three main principles:

- Systems are checked on installation and after relevant modification, before starting new charters, and immediately before and periodically during use.
- Operational capability is matched by operational status.
- The procedures adopted should take account of the limitations of the system.
- These principles lead to several outline operating procedures, which are explained below.

**1. DP Proving Trials**

All the precautions and procedures described herein will be to no avail if the DP system includes uncorrected faults remaining after its original construction. Before a DP diving vessel undertakes DP diving operations after construction or any relevant modification, it should undergo a full series of trials.

These should include testing and tuning in harbor, followed by sea trials, during which the vessel's position-keeping system should be thoroughly tested under normal and breakdown conditions, and should culminate in a DP bell dive. It is stressed that commissioning of systems, piece by piece, cannot replace the need for thorough testing of the total system under working conditions. It is likely that such trials, if properly conducted, would take several days. Where possible, they should be performed partly in a situation where accurate monitoring of the vessel's position can be achieved and partly in open water under realistic environmental conditions. The results of these trials should be used to confirm or refine the vessel's performance capability statements.

As an indication of appropriate DP proving trials, checks of the following could be made:

- **In Harbor**
  - Correct fitting and mounting of all equipment and cabling.
  - Correct wiring of all power supplies, data cabling and equipment.
  - Correct functioning of all equipment (including data input systems, computers, interfacing equipment, thruster units and power supplies) by electronic and functional testing.

- Effective shielding of all potential sources of electrical interference (including those that may be used only intermittently)
    - Software checks and tuning.
    - Correct functioning of all condition monitoring systems and alarms.
- **At Sea**
    - Correct functioning of all data input systems.
    - Correct functioning of computers and interfacing.
    - Correct functioning of power management systems.
    - Correct functioning of thrust units, including response times.
    - Optimum position-keeping performance by fine-tuning of software.
    - Insure position-keeping accuracy using independent means.
    - Correct functioning of all automatic and manual change-over arrangements and procedures from primary to backup systems.
    - Correct functioning of offset and heading change control.
    - Satisfactory operation of DP system, with bell running and then with divers in water.
    - Position-keeping per ordinance in rough weather.

It is stressed that this list is not definitive, but is included as an indication of the type of testing required.

**2. New Charter Assessments**

In fulfilling their responsibilities under national regulations, diving contractors and field operators whose operations involve the use of DP diving vessels should, before they permit DP diving operations to be carried out, satisfy themselves about the vessel's suitability for the operations planned. This could involve a thorough assessment of a vessel's DP arrangements in line with these guidelines, including a study of relevant documentation, such as operations manual, FMEA report, capability plot and any other form of DP system assessment available together with summaries of the experience of personnel involved with DP operations based on their operators logs. It should also include a short sea trial during which the actual capability of the vessel and crew to support DP diving in both primary and breakdown conditions is assessed. Such trials could, if the vessel is satisfactory, be completed in eight to 10 hours.

**3. Operating Checks**

A program of functional checks designed to test the operation of a DP system, including the selection and operation of backup systems, should be performed whenever setting up on DP. For example, these could include (but are not limited to) simulation of failures of online components such as a DP computer, a position reference sensor, a gyro, a generator or a thrust unit. They could also include commanding offsets in both direction and heading. In addition to the successful completion of these checks, the vessel should have held station automatically within the defined degree of accuracy until the master and senior diving supervisor are confident that the system is reliably set up before diving operations are permitted to start. This may take at least 30 minutes.

Repositioning of a vessel under DP control would not require a repeat of this check period. It is recommended that some or all of these checks be repeated periodically while on DP, but when diving is not being carried out and positionkeeping is not crucial. By doing so, the continued correct functioning of the system can be checked while the readiness of operators to deal with emergencies is enhanced. Instructions for the performance of these checks should be prepared and written by the vessel owner with the assistance of the DP system manufacturer and could be produced in the form of a checklist in a card or folder for ease of use. A more comprehensive arrangement could be provided by a purpose-built simulator.

**4. DP Alerts**

When diving on DP, a clear system to indicate and guide responses to operational capability is important. This system should be based on a minimal number of standard operating status levels representing the capability of the DP system to retain the vessel on station within safe limits. It is recommended that these levels should represent the following conditions:

- **Normal Operational Status (Green Light)**

  The vessel can be defined as in normal operational status when all of the following conditions apply:
    - The vessel is under DP control, and the DP system is operating normally with appropriate backup systems available.
    - Thruster outputs and total power consumption (where applicable) do not exceed 80 percent of maximum thrust and total available power, respectively, for more than brief and isolated periods.
    - Vessel's indicated position and heading is within predetermined limits for all but brief and isolated periods. These limits should he determined for each location.
    - No risk of collision exists.

- **Degraded Operational Status (Yellow Alert)**

  The vessel can be defined as being in degraded operational status when any of the following conditions applies:

  - There is a failure in a sub-system, leaving the DP system in an operational state (possibly after reconfiguration) but with no suitable backup available so that an additional fault occurrence could result in DP system breakdown and assumption of emergency status.
  - Available power units are reduced to the extent that failure of one more could prevent the vessel holding position or heading in existing or foreseeable conditions.
  - Available thrust units are reduced to the extent that failure of one more could prevent the vessel holding position or heading in existing and foreseeable conditions.
  - With all available thrust and power units online, any thrust unit output exceeds 80 percent of its maximum thrust, or total power consumption exceeds 80 percent of total available power for more than brief and isolated periods. Vessel's indicated position deviates beyond predetermined limits for more than brief and isolated periods.
  - Risk of collision exists.
  - Weather conditions are judged to be becoming unsuitable for DP diving.

- **Emergency Status (Red Alert)**

  A vessel can be defined as in emergency status if either of the following conditions applies:

  - System failure results in inability to maintain positioning or heading control.
  - Any external condition exists, including imminent collision, which prevents the vessel from maintaining position.

**5. Alert Level Responses**

The following responses could be made to different alert levels. Visual and audible signals should be manually initiated by the DP operator.

- **Normal Operational Status (Green Light)**

  Full DP diving operations can be undertaken.

- **Degraded Operational Status (Yellow Alert)**

  The master and senior diving supervisor should be informed. The diving supervisor should be informed. The diving supervisor should order the diver(s) to return immediately to the bell and obtain a seal. A decision should be taken by the senior diving supervisor, in conjunction with the master, in the light of prevailing conditions and any possible mitigating actions available, whether to abort the dive or, where surface-supplied diving is being conducted, prepare to return to the surface. Under this condition, air or mixed-gas divers should be ordered to return to the surface.

- **Emergency Status (Red Alert)**

  The diver(s) should be ordered immediately to return to the bell and obtain a seal. The diving supervisor should order the bell to be recovered as soon as possible after consideration of hazards involved in doing so (e.g., fouling of anchor wires, jacket members, etc.) or, where surface-supplied diving is being conducted, prepare to return to the surface. The DP operator should use all means available to maintain the vessel in position until the divers are sealed in the bell and the bell is clear of obstructions. The diving supervisor and master should be verbally informed as soon as possible. Under this condition, air or mixed-gas divers should be ordered to return to the surface.

**6. Communications**

Communications between the dive control position and the DP console should be regular and frequent. Each watch-keeper should inform the other about any change in operational circumstances that occurs or that is planned.

The following list gives an indication of the type of information that should be passed:

- **Dive Control to DP Operator**
  - Bell status.
  - Diver status.
  - Intention to use water jetting or other underwater equipment.
  - Possibility of divers, bell equipment, etc., blanking or moving acoustic reference signals.
  - Any situation that could develop into an emergency.
- **DP Operations to Dive Control**
  - Intention to move vessel.
  - Any change in operational status.

- Background information on causes of changes in operational status.
- Any forecast or actual significant changes in weather.
- Ship and helicopter movements in the vicinity.
- Intention to handle down-lines of any description, including repositioning taut wire weight.
- Intent to bring small boats alongside.
- Intent to place anything into the water.

The following list indicates the type of information needed by the DP operator about activities in the vessel:

- Intention to perform and notification of completion of any electrical or mechanical system maintenance or modification that could directly affect online DP equipment or make standby equipment unavailable.
- Intention to start and stop ancillary air/hydraulic units that may reduce pressure on DP or diving-associated equipment.
- Intention to start and stop pumping of bilges, discharge of sewage, galley waste, etc.
- Intention to start and stop the use of radio and radar equipment that may affect the DP system.
- Intention to handle equipment that may affect the trim of the vessel.
- Imminent arrival or departure of helicopter or vessel alongside.

The following list indicates the type of information that should he passed between the DP operator and the platform:

- **Platform to DP Operator**
  - Planned movements of vessels and helicopters.
  - Planned crane lifts or outside platform work that could interfere with the diving operation, beacon or transponder sites.
  - Intention to discharge mud, galley waste, etc.
  - Planned blackouts in communications or power and hazardous operations (e.g., well-tests).
  - Weather information.
  - Other subset operations.
- **Taut Wire Systems**
  - Regular inspection and maintenance of the wire should be carried out. It should also be cut back and re-secured to the weight frequently to ensure that wear does not become excessive at either the weight or the sheave.
  - Care should be taken in the choice of its position in the vessel to minimize the mechanical limitations of the system. This is particularly important in higher sea states due to the movement of the vessel. It should also be situated as far as practicable from the moon pool or other diving position.
  - Care should be taken to ensure that the taut wire does not lift off the bottom or, if it does, that an indication of it having done so is given automatically to the DP operator. Measures should be taken to prevent danger to divers if the taut wire is moved and to avoid interference with the taut wire by divers.
  - The taut wire should be lowered to a position as far as possible from subsea pipelines, flow lines or cables, any of which may move. The mechanical limitations to the angle at which the taut wire can effectively operate introduce a limit to the distance from the intended position to which a vessel may deviate. This is of particular importance in shallow water.
- **Short-Range Radio Systems**
  - Vessel operators should be aware of the possibility of temporary loss of information (e.g., due to blanking by other vessels, helicopters, platform equipment, or occasionally rain squalls), and action should be taken to avoid or minimize the effects of this.
  - Remote beacons or transponders mounted on manned production platforms are vulnerable to manual interference. Steps should be taken to ensure that they are not tampered with or "blanked off" and that their power supplies are not interrupted. This could include providing battery backup, connection to the platform's essential service supplies, and placement in accessible positions in accessible positions. A warning signal should indicate that the main power supply has been cut and the system is working on batteries. The owner of the platform should be responsible for the security of equipment located on the platform.
  - Where possible, alterative frequencies or codes should be prepared to cover the possibility of interference but should be allocated with care.
  - The vessel's position and resulting reference station geometry should be carefully considered whenever a move is contemplated.
  - Interference from radar can cause temporary signal failure or error.

**7. Down-line Handling and Interference with DP Sensors**

The handling of all down-lines from DP ships requires special care in the following respects:

- **Taut Wire Errors**

  Long, horizontally-slung objects that can pivot when suspended in the water can and have come into contact with taut wires that are providing positioning information. Care should be exercised to avoid this.

- **Snagging of Divers**

  Any down-line can snag a diver. Down-lines should be handled only by people experienced in doing so and under supervision of the diving supervisor, if necessary, via the bridge. This is particularly relevant when the vessel is being moved.

- **Moving Acoustic Beacons or Transponders**

  Acoustic devices should be moved only by divers under the supervision of the diving supervisor and on the direct authority of the master, who should be continuously advised of their movement.

- **Down-lines**

  Down-lines should be made up to include a breaking section to reduce the chances of injury to divers.

**8. Uncontrolled Movement**

The conduct of diving operations from DP vessels, as opposed to other types, requires particular attention to the risk to divers due to vessel movement. The effect of the vessel moving off station can cause failure of main lift wires, life-support and/or communication arrangements between the vessel and bell, vessel and diver(s), or bell and diver(s).

Operating and emergency procedures should be established to minimize the risks, and adequate arrangements should be made for the provision of emergency life-support, communications and relocation devices to allow a successful recovery. The bell or divers should always be positioned with care, and whenever possible, above the level of potential obstructions. The possibility of releasing the tension on the winch wire, umbilical, and clump weight wire, while the bell is deployed, should be considered to avoid dragging it if position is lost.

Generally, divers should not enter confined spaces when diving from DP vessels. However, in special circumstances and with due regard to the provision of particular means to ensure their safety in case of DP failure, such operations may be permitted.

**9. Operations Plot and Emergency Plans**

A plot displaying the relative positions of the vessel, the bell, divers, the worksite and any known obstruction (e.g., platform, other vessels, mooring wires, wellheads, etc.) together with ship's heading and wind direction and speed should be maintained at all times at the DP control position. The DP watch-keepers should ensure that this plot is always kept up-to-date and that planned emergency procedures have been approved by the diving supervisor to provide for the action to be taken in case of DP or other emergency. These plans should be produced in advance of any diving operations and be reviewed and modified as appropriate.

**10. Vessel Movement Limitations**

When the bell is launched or divers are deployed, DP diving vessels should be moved only with the full knowledge and consent of those concerned (in particular the divers) under very restricted and controlled circumstances, as follows:

- Under automatic DP control.
- Generally, the vessel should not be moved while divers are in the water. However, in special circumstances and with due regard to hazardous obstructions, the master, with the agreement of the diving supervisor, should be able to authorize limited vessel movements with the divers in the water directed by the diving supervisor. Such movements should not exceed the limitations of the reference sensors and should be made at slow speed. Heading changes should not exceed 15%. When moving, bell divers should be in the close vicinity of the bell (i.e., on the clump weight). .
- Limited movements of the vessel that are greater than those described above should be made only where divers have been recovered to the vessel and with bell divers inside the bell recovered to the vessel or positively clear of any potential hazardous obstructions, including the seabed.
- When moving the vessel on DP, particular consideration should be given to:
  - Where the bell is cross-hauled or the vessel's vertical axis of rotation does not coincide with the moon pool, in addition to the limitations established above, heading changes should not exceed an angle that causes a 10-meter movement of the bell.
  - The possible snagging of down-lines with the bell winch wire and umbilical.

**11. DP Operations in Vicinity of Platforms, Etc.**

Particular care must be exercised when operating on DP in close proximity to fixed objects, such as production platforms, mooring buoys, etc. When DP diving is undertaken in the vicinity of anchor wires and cables, the inaccuracy in the knowledge of their actual position at any particular time, and the resulting need to keep the bell and bell wires as far from them as possible, should be taken into account.

**12. Visual Reference Points**

When close to fixed structures, their value as a visual reference to provide an early additional indication of DP failure should be considered.

**13. DP Operations in Vicinity of other DP Vessels**

When operating on DP close to one another, DP vessels are potentially subject to several forms of mutual interference. These include thruster wash, which may affect both hulls and taut wires; acoustic and radio position reference sensor signals; and intermittent shelter from wind and sea. These factors should be considered when planning such operations and due allowance made for them. This may take the form of assuming less-accurate position-keeping tolerance than would nominally be expected, but it could also include coordination of choice of position reference sensors and frequencies and careful choice of the relative positions of the vessels.

**14. DP Operations in Shallow Water**

During shallow-water operations, there are indications that the limitations of acoustic and taut-wire reference sensors, in terms of the distance from the intended position at which these sensors can operate correctly, can introduce an extra hazard above those normally associated with their use in deep water. The need to use a surface reference sensor as one of the sensors in such operations is therefore of particular importance. The effect or the strong tidal streams and currents sometimes associated with shallow water should also be taken into account in relation to the position-keeping capabilities of DP vessels.

**15. Weather Precautions**

Due regard should be paid to any indications of impending weather changes, in particular sudden wind shifts and/or gusts. In winter, sudden changes in direction and increases in strength of wind often occur. The use of onboard meteorological instruments, including barometers, barographs, wind sensors (both fixed and portable), and wet and dry thermometers is necessary to ensure that timely action is being taken to reduce the possibility of loss of position.

In conditions where wind and waves are from opposite sides of the fore and aft line of a vessel, particular care is required, as a wind shift to coincide with wave direction is likely to cause rapid change in resultant force on the vessel. A warning of instability when the weather is from roughly ahead or astern, to be obtained from thrust unit movements alternating frequently through 180º using appreciable thrust. A case has occurred of a complete power failure resulting from a DP ship being struck by lightning. All reasonable precautions in accordance with good marine practice should be taken to ensure that forecasts of changing weather conditions are obtained and acted upon.

These precautions should include:

- Obtaining regular and frequent weather forecasts for the area of operations and use of facsimile facilities and charts.
- Seeking information by radio from other units in the vicinity about prevailing weather conditions in their areas.
- Use of experience and a "seaman's eye" in assessing the prevailing conditions and likely trends.
- The presentation of environmental information measured by the DP system and any trends in conditions that it can provide.

**16. Collision Risk**

Care should be exercised at all times to ensure that the correct lights and shapes are displayed in accordance with the latest international collision regulations . By the present rules, whereas power-driven and sailing vessels are required to keep out of the way of a vessel restricted in its ability to maneuver (e.g., a DP diving vessel), a vessel engaged in fishing when underway is required only "so far as possible" to do so.

The master of a DP diving vessel should give early warning that it is unable to maneuver to any vessel that appears to be on a collision course using visual and sound signals. The potential use, if properly employed, of a simple automatic collision warning system should not be overlooked. In conditions of reduced visibility, decisions about the suitability of conditions for diving should rest with the master of the vessel.

## 8.3.8 PERSONNEL CAPABILITIES

The third principle (personnel capabilities) concerns the ability of the personnel onboard to perform the tasks entrusted to them. There should be sufficient personnel having suitable training and experience to ensure the safety of the vessel and all those on board.

### 8.3.8.1 Authorities

Nothing in these guidelines shall supersede the spirit or letter of legislation covering the authorities of masters of merchant vessels, of supervisory staff responsible for diving, project control, and of offshore installations. It is, however, of fundamental importance that the authorities of all personnel concerned with the management of diving operations conducted from DP vessels be thoroughly and clearly defined. The sections below give general guidelines.

**1. The Master**

The master of the vessel is ultimately responsible for the safety of his or her vessel and all personnel on board and has ultimate authority to forbid the start or order the termination of diving and DP operations on grounds of safety to personnel on the vessel.

**2. Operations Superintendent**

The operations superintendent, where present, is responsible for the conduct of all operations carried out from the vessel. As such, he or she has authority to forbid the start or order the termination of diving operations for safety or other reasons. The operations superintendent may not order the start of diving operations.

**3. The Diving Supervisor**

The diving supervisor is appointed by the employer of the divers to be in overall charge of all diving operations from the vessel and is responsible for all aspects of diving safety. He or she has ultimate authority to permit or forbid the start and order the termination of any diving operations on grounds of diving safety. Other diving supervisors may, as necessary, be appointed by the diving contractor but should be under the control of the diving supervisor. For the purposes of these guidelines, it is assumed that any additional diving supervisors have been vested with the authority and operational responsibility of the diving supervisor when on duty and until relieved.

**4. The Client's Representative**

The client's onboard representative should, in conjunction with the contractor's senior onboard representative, be responsible to the client for the proper performance or all work in accordance with the contract. He or she may request the start of DP or diving operations and should have the authority to veto the start or order the termination of diving or DP operations on any grounds.

**5. Project Liaison**

In view of the additional safety factors involved in DP operations, it is essential that close liaison be maintained between the various authorities concerned. Some organizations may include additional supervisory roles, but the above four authorities should represent the minimum forum for planning meetings concerning DP supported diving operations.

**6. Priorities**

Priorities should be clearly established for dealing with a DP emergency. The authorities of the master and diving supervisor are of fundamental importance at such times. They should cooperate closely to these priorities so that there is no room for doubt or dissension. Priorities should take into account that:

- The safety of life is the first priority. The master has ultimate authority to assess and decide on courses of action in this respect. The advice of the supervisor should be taken into account.
- The safety of property is of lower priority. No effort should be made to safeguard property at the expense or safety to life, but the potential danger to life which some threats to property pose should not be overlooked. The advice of the client's representative and offshore installation owner should be heeded where possible in respect of the safety of offshore installations and equipment.

**7. Manning for DP Diving Operations**

The requirements for numbers of qualified DP operators will vary. However, every DP vessel engaged in diving operations should meet the following requirements:

- The master of a DP diving support vessel, when performing DP diving operations, should be appropriately trained to be responsible for operating the DP system without supervision.
- DP Operators should be present in the DP control room whenever DP diving operations are being carried out. One of them should hold an appropriate deck officer's qualification to be in charge of the navigational watch. One should be responsible for operating the DP system without supervision. The other should have received suitable instruction on the principles and operation of DP systems. The second watch-keeper may leave the DP control room to attend to ship's business.
- An appropriately trained technician capable of minor fault-finding and maintenance of the DP system should be onboard at all times when DP operations are taking place.
- The period of time for which the watch-keeper referred to above continuously operates the DP system should be limited to avoid loss of concentration. It is unlikely that continuous periods of longer than two hours would be satisfactory, and in some circumstances this may need to be shortened.
- Engine rooms (or engine control rooms) should be manned at all times when on DP.

### 8.3.8.2 Training and Experience

The amount of training and experience needed by personnel to perform their functions safely varies. However, the following minimum standards are recommended, but some may need to be exceeded in some cases:

- No person should be responsible for operating the DP system in a DP diving vessel without supervision while diving operations are in progress, until he or she has:
  - Received suitable instructions on the principles and operation of DP systems.
  - Attained satisfactory practical experience by completing a suitable period of supervised DP watch-keeping offshore during which he or she has simulated the main subsystem failures, including failure of automatic computer control. It is suggested that a suitable period would be at least 200 hours.
  - Satisfactorily completed approximately 50 hours supervised DP watch-keeping on the vessel concerned during which he or she has simulated the main sub-system failures. To assist the owners to monitor this training, it is recommended that all DP operators maintain a personal log of their DP experience.
  - The technician(s) responsible for minor fault finding and maintenance of the DP control system should have satisfactorily completed a suitable training course.

### 8.3.8.3 Operations Manual and Records

Clear guidance about the operation of each individual DP diving vessel should be contained in an operations manual prepared specifically for that vessel. The manual should contain sections on at least the subjects outlined in the following subparagraphs.

**1. Vessels Operational Limitations and Alert Procedure**

The limitations and procedures as defined in Section 8.3.7.5(4) DP Alertsshould be clearly stated.

**2. Manning**

This section should detail the minimum manning arrangements for the vessel when operating on DP and during diving operations.

**3. Responsibilities, Authorities and Duties**

The duties, responsibilities and authorities of senior personnel should be described based on the guidance in Section 8.3.8.

**4. DP Operations**

A description of the DP system fitted on the vessel and guidance on the performance of all DP operations, including procedures for:

- Operating checks.
- Operations of position-reference sensors.
- Duration of DP operating periods.
- Operations in the vicinity of platforms, etc.
- Standard alert levels (with description of warning signals).
- Precautions with regard to weather.
- Measures to prevent collision.

**5. Diving Operations**

An up-to-date description of the diving system(s) and guidance on the conduct of diving operations as they may be affected by the DP vessel itself, including procedures for:

- Actions to be taken in case of changes in alert-level status.
- Operation of divers in free-flooding and enclosed spaces
- Precautions to guard against thrust unit wash or suction effect.
- Surface support and down-line handling.
- Information to be provided to dive control positions.
- Preparation and use of emergency plans.
- Moving vessel.

**6. Priorities**

Guidance should be given on the priorities to be adopted in case of emergency. These should follow the guidance given in 8.3.8.1 (No. 6).

**7. Communications**

Guidance and procedures concerning the transfer of information should be modified to suit the particular vessel. This section should also contain a description of the voice communication systems and alarm systems that are available and should define emergency situations.

**8. Records and Report**

Details of all records and reports required by the master, senior diving supervisor and others.

### 8.3.8.4 Information Feedback

Lessons learned in the course of practical DP operations can be of use to others besides those immediately involved. Arrangements for the dissemination of information should he established, so that relevant practical experience and the lessons learned can be made available to others to improve the safety of DP diving operations. This may include dissemination within the vessel and/or the company, and to designers, manufacturers and shipyards.

### 8.3.8.5 References

International Maritime Organization Publication 645 Guidelines for Vessels W/D

## 8.3.9 SURFACE-SUPPLIED DIVING FROM DYNAMICALLY POSITIONED VESSELS

**All equipment and manning levels should be considered the recommended minimum for approaching this diving application, based on one dive and any applicable decompression required. Increased manning levels and additional equipment may be required for any diving in excess of one dive and any decompression required. Proper pre-job planning should be conducted to ensure that the necessary levels of personnel and equipment are available for diving operations.**

1. Minimum Personnel
    - One air or mixed-gas diving supervisor (NOT part of the dive rotation).
    - One manifold operator when mixed-gas [$HeO_2$] diving.
    - One diver.
    - One standby diver.
    - Two tender/divers.
    - Two LARS/Winch Operators

### 8.3.9.1 Surface-oriented Diving

The following conditions must be met to perform surface diving from a DP vessel in the DP mode whether over the side or through the moon pool:

- Utilization of an open-bottom bell with emergency on-board gas. (For air or nitrox dives, a stage with emergency on-board gas may be substituted for an open-bottom bell.)
- A tending point on the surface or in-water from which the diver's umbilical can be securely tended. Allowable tending methods need to be addressed in the project JHA and may include the following items:
    - A tender located on the vessel;
    - A tender located in a stage above the surface;
    - An unmanned in-water tending point (e.g. open-bottom bell, diver's hoop {golden gate};
    - An in-water tender;
- Divers (and, if utilized, in-water tender) to have access to surface and on-board gas.
- The bell umbilical and/or diver's umbilical supplying the wet bell and/or divers with appropriate services must be secured to the main lift wire (or secondary lift wire).
- The Diver's (excursion) umbilical is secured to the wet bell so that it is at least 16 feet shorter than the distance to the closest hazard. The umbilical must be appropriately marked.
- Bell umbilical and surface umbilical management plan (should be filed with JHA).
- The diving supervisor must be provided with relevant DP alarms and communications systems to the bridge and/or DP control station.
- The topside tenders must be able to hear all communications between the divers and the supervisor and must be able to talk directly to the supervisor.
- Written procedures, as most regulations in effect in other nations, must be prepared for emergency situations (e.g. changes in alert-level status, alarms, loss of communications, moving the vessel, etc.).
- The dive crew must be familiar with the vessel's overall design and operating characteristics (e.g. position of thrusters, propellers, intakes, obstructions, etc.).

**NOTE: During diving operations, it is recommended that all structures or debris should be deeper than the deepest point of the bell to protect the bell in the event** of **runoff or black ship circumstances. Operations where the bell is below the shallow point of the underwater obstruction shall require a management of change (MOC).**

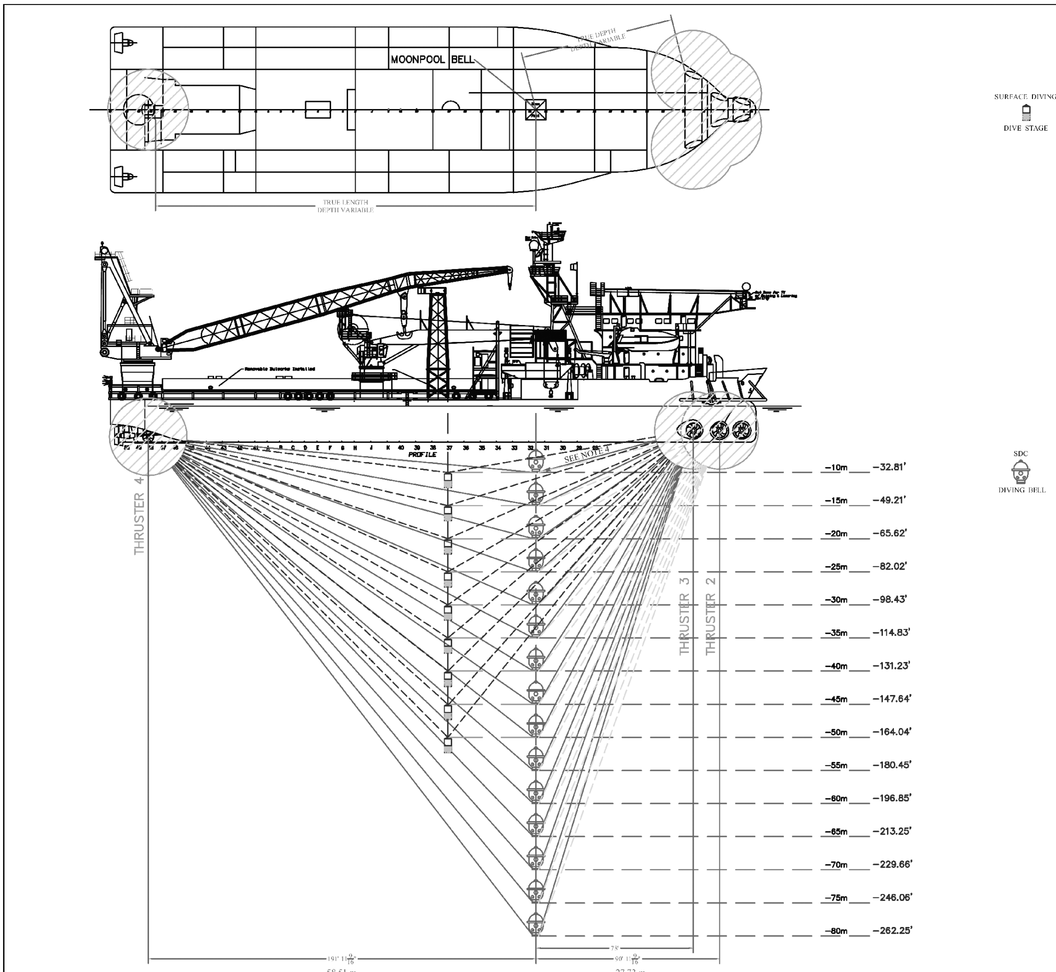
The following requirements for surface and saturation diving operations conducted from a vessel are in effect only when the vessel is operating in the DP mode. "DP mode" is defined as whenever there is any form of motive power in operation, e.g. thrusters or propellers, which automatically maintains the vessel's position (fixed or a predetermined track) by means of thruster force. The DP system consists of a power system, a thruster system, a DP-controlled system with the redundancy built in to maintain or restore its function, e.g. DP II and DP III. Diving operations conducted from a DP II or DP III vessel should not be considered "Live Boating" and may be performed at any time during the day or night, provided a thorough hazard assessment has been performed. The requirements are based on the premise that at no time should the length of umbilical from the tending point to the diver allow the diver to come into contact with the nearest thruster or propeller that is in operating mode. Very great care is needed in the planning and execution of shallow and surface-oriented diving operations to minimize the effect of thrust units on the divers. The effects of thrust unit wash or suction should be carefully considered, and precautions should be taken to guard against them, particularly when the bell or divers pass the potential wash zone. These precautions could include appropriate computer software to avoid any hazardous effects on the operation of the bell or divers.

The use of thrust diagrams when planning dives can also help. Inhibiting or deselecting certain thrusters may be necessary, and the resulting reduction in the vessel's operational limitations should be taken into account. Divers' umbilical lengths and the manner of deploying them (e.g. over the side, from the bell, etc.) should be so chosen that divers and their umbilical are physically restrained from going to positions where they or their equipment could come into contact with the thrust units or be adversely affected by their wash. Furthermore, care should always be taken to prevent umbilical developing a bight, and to respond at once to any indications of a diver being in difficulty, such as unusual tension on or at the angle of the umbilical. There is no simple approach to the problem due to the differences encountered in the vessels and worksites.

### 8.3.9.2 Bell Umbilical Management and Surface Umbilical Management

**-SAMPLE DIAGRAM ONLY-**

**Safe Umbilical Length Formula**




SURFACE DIVING
DIVE STAGE

| SURFACE DIVER MAX. UMBILICAL LENGTHS | | | |
|---|---|---|---|
| DEPTH | MAX EXCURSION FROM AFT THRUSTER No 4 | MAX EXCURSION FROM FWD THRUSTER No.3 | MAX EXCURSION FROM FWD THRUSTER No.2 |
| -10m | 39.70m ( 130.25' ) | 31.75m ( 104.17' ) | 35.65m ( 116.96' ) |
| -15m | 40.55m ( 133.05' ) | 32.91m ( 107.97' ) | 36.70m ( 120.42' ) |
| -20m | 41.92m ( 137.53' ) | 34.66m ( 113.70' ) | 38.30m ( 125.66' ) |
| -25m | 43.76m ( 143.56' ) | 36.92m ( 121.13' ) | 40.38m ( 132.49' ) |
| -30m | 46.02m ( 150.97' ) | 39.62m ( 129.99' ) | 42.90m ( 140.73' ) |
| -35m | 48.59m ( 159.43' ) | 42.69m ( 140.06' ) | 45.77m ( 150.16' ) |
| -40m | 51.57m ( 169.21' ) | 46.06m ( 151.11' ) | 48.95m ( 160.59' ) |
| -45m | 54.78m ( 179.74' ) | 49.63m ( 162.84' ) | 52.34m ( 171.72' ) |
| -50m | 58.22m ( 191.02' ) | 53.49m ( 175.49' ) | 56.04m ( 183.84' ) |

NOTES:

1. THIS DRAWING OVERRIDES ALL PREVIOUS VERSIONS
2. ALL LENGTHS CALCULATED FOR 5.87m DRAFT
3. WORST CASE SCENARIO USED TO DETERMINE SAFETY EXCLUSION ZONE TO NEAREST THRUSTER/AZIMUTH FROM DIVING BELL.
4. DIVER MAXIMUM UMBILICAL LENGTHS (TO THE NEAREST THRUSTER ) = FOR VARIABLE DEPTHS
5. MEASUREMENT POINT FOR BELL UMBILICAL IS EDGE OF BELL TRUNK. FOR STAGE , IT IS TOP OF STAGE.
6. BELL TRUNK DIAM. = 800mm
7. LENGTHS INCLUDE SAFETY DISTANCE OF 5m FROM THRUSTERS ( see Safety Exclusion Zone note, below).

SDC
DIVING BELL

| BELL DIVER MAX. UMBILICAL LENGTHS | | | |
|---|---|---|---|
| BELL DEPTH | MAX EXCURSION FROM AFT THRUSTER No 4 | MAX EXCURSION FROM FWD THRUSTER No.3 | MAX EXCURSION FROM FWD THRUSTER No.2 |
| -10m | 52.50m ( 172.24' ) | 19.04m ( 62.47' ) | 22.30m ( 73.16' ) |
| -15m | 53.17m ( 174.44' ) | 20.85m ( 68.41' ) | 23.84m ( 78.22' ) |
| -20m | 54.25m ( 177.99' ) | 23.45m ( 76.94' ) | 26.10m ( 85.63' ) |
| -25m | 55.72m ( 182.81' ) | 26.67m ( 87.50' ) | 28.94m ( 94.95' ) |
| -30m | 57.55m ( 188.81' ) | 30.33m ( 99.51' ) | 32.23m ( 105.74' ) |
| -35m | 59.72m ( 195.93' ) | 34.33m ( 112.63' ) | 35.87m ( 117.68' ) |
| -40m | 62.17m ( 203.97' ) | 38.55m ( 126.48' ) | 39.77m ( 130.48' ) |
| -45m | 64.90m ( 212.93' ) | 42.95m ( 140.91' ) | 43.88m ( 143.96' ) |
| -50m | 67.87m ( 222.67' ) | 47.49m ( 155.81' ) | 48.14m ( 157.94' ) |
| -55m | 71.05m ( 233.10' ) | 52.11m ( 170.96' ) | 52.51m ( 172.28' ) |
| -60m | 74.42m ( 244.16' ) | 56.83m ( 186.45' ) | 56.99m ( 186.97' ) |
| -65m | 77.94m ( 255.71' ) | 61.60m ( 202.10' ) | 61.53m ( 201.87' ) |
| -70m | 81.61m ( 267.75' ) | 66.42m ( 217.91' ) | 66.13m ( 216.96' ) |
| -75m | 85.41m ( 280.22' ) | 71.29m ( 233.89' ) | 70.79m ( 232.25' ) |
| -80m | 89.33m ( 293.08' ) | 76.20m ( 250.00' ) | 75.52m ( 247.77' ) |

MAX STANDBY UMBILICAL LENGTHS MAX DIVER LENGTHS +2m

BELL TRUNK TO THRUSTER 3
BELL TRUNK TO THRUSTER 2

- SAFETY EXCLUSION ZONE DRAWN AT 4.73m FROM THE OUTER EDGES OF THRUSTER HOUSINGS

STAGE & BELL DIVER'S EXCURSION LIMITS

A0

1:150

**$A^2+B^2=C^2$**

**The square root of $C^2$ = Distance to hazard**

**A = Distance to nearest hazard (stern thruster)**

**B = Shallowest depth diver will leave bell**

**C = Distance from depth to nearest hazard**

**Items 1 and 2 below must be subtracted from (C) to determine maximum safe umbilical length.**

1. **MAIN umbilical must be 16 feet (5m) shorter than (C) closest hazard.**
2. **STANDBY umbilical must be 10 feet (3m) shorter than (C) closest hazard.**

# SECTION 9.0

# REMOTE OPERATED VEHICLES (ROVs)

Association of Diving Contractors International, Inc.

# 9.0 REMOTE OPERATED VEHICLES (ROVs)

## 9.1 INTRODUCTION

The purpose of the guidance contained in this section is directed to the use of ROVs within the commercial diving and underwater industry and to provide general material intended to contribute to the highest possible degree of safety during the conduct of ROV operations. **For specific guidelines and procedures for ROV diver operations, refer to Section 9.3.**

## 9.2 BACKGROUND

Implementation of these guidelines will vary depending upon the class of ROV used, and it is important to recognize that the great diversity and variety of vehicles make it difficult to definitively state into which class a particular ROV may fall.

The term "remote-operated vehicle" (ROV) covers a wide range of equipment, with no single vehicle able to be described as typical. Not only are there numerous differences between basic designs, but the same basic ROV can be modified to carry out different tasks. For the purpose of this standard, four different classifications are identified, but it should be recognized that there can be subdivisions within these classes. For example, ROVs launched and recovered in a "garage" or "cage" with a tether management system may be subdivided from those that are free-swimming. Likewise, a large work-class ROV may be tracked just as a small observation vehicle can be mounted to tracks for specialized operations in the observation mode.

### 9.2.1 CLASSIFICATION SYSTEM

**Class I – Small/Micro Class ROVs.** Small/Micro vehicles are generally physically limited to video observation and fitted with a video camera, lights, and thrusters. Newer generation class I vehicles can also carry single-function manipulators, acoustic sonars, and other small accessories. Class I vehicles are typically influenced by water currents and can be power limited.

**Class II – Observation Class ROVs.** These vehicles are generally somewhat larger than Class I ROVs and are capable of carrying additional sensors, such as still cameras, cathodic potential measurement devices, additional video cameras, sonar systems, and multifunction manipulators. Class II vehicles should be capable of operating without loss of original function while carrying at least two additional sensors. These vehicles typically require a crane to deploy and retrieve. These vehicles have the capability to overcome moderate water currents and can have multiplexing capability.

**Class III – Light Work Class ROVs. These vehicles are large enough to carry additional sensors and/or manipulators and commonly have a multiplexing capability to allow additional sensors and tools to operate without being "hard-wired" through the umbilical system. These vehicles are generally larger and more powerful than class I and II vehicles. Wide variations of power, depth rating, and capability are possible.**

**Class IV – Heavy Work Class ROVs.** These vehicles are the largest ROV and will carry multiple sensors, manipulators, and other tooling options in the standard configuration. These vehicles are the largest and most powerful of any ROV class..

**Other Vehicles – Manned Submersibles, AUVs, and towed systems.** These other vehicles may require similar competencies for the pilot - technicians but are not covered under this consensus standard.

### 9.2.2 ROV TASKS

**Observation.** Observation is the least complicated work mode. It can normally be undertaken by the use of a video camera without additional equipment and is generally conducted by ROV s of Class I or Class II variety. If the monitoring of divers is entailed, the vehicle will normally be maintained in a near-stationary position.

**Survey.** Surveying activity normally consists of some form of observation of the intended area of operations, whether on the seabed or within an enclosed area such as a pipeline, outfall or tank-like structure. Surveys can also be employed as a post-construction or equipment installation verification tool.

ROVs conducting survey operations may employ several different types of acoustic sonars and subsurface positioning systems.
Advancements in technology have allowed for some class I and nearly all of class II and above ROVs to perform advanced survey operations.

The general purposes of surveying activity may be:

a. Fixing geographical coordinates.
b. Ensuring the target structure or device is within a permitted corridor or area.
c. Verification of burial.
d. Determination of physical damage.
e. Examination of pipelines or structures.

f. Verification of debris removal.
g. Identification.

**Inspection.** It is often difficult to distinguish between inspection and survey, particularly as an ROV may carry out both types of tasks in a single dive. Inspection tasks usually concentrate on specific, pre-defined areas of concern and include detailed visual and/or other types of inspection using onboard sensors such as cathodic protection (CP) measurement devices.

**Construction.** These tasks normally require a larger vehicle capable of deployment of at least one manipulator. Construction vehicles may be employed in such tasks as removal of debris, intervention, connection or removal of lifting devices, or actuation of valve components. Intervention. Many work-class ROVs have specially designed tool packages able to interface with subsea manifolds, wellheads, or control pods to effect installation, removal, and maintenance or repair functions.

**Intervention.** Many work-class ROVs have specially designed tool packages able to interface with subsea manifolds, wellheads, or control pods to effect installation, removal, and maintenance or repair functions..

**Burial and Trenching.** Some ROVs fitted with suitable trenching equipment are used where soil characteristics are favorable for burial or trenching operations.

**Science.** ROVs across all classes are widely used for scientific research activities for governmental, academic, and other research agency activities.

**Aquaculture.** ROV application to the fisheries and aquaculture industries includes offshore production and fish farming facilities along with regulatory and compliance investigations**.**

**Military, Homeland Security and Public Safety.** Developments in ROV and sensor technologies have opened numerous opportunities for ROV support in the areas of mine countermeasures (MCM), retrieval/recovery, and other security inspection tasks.

### 9.2.3 ROV TOOLS

Tool packages can be varied to suit requirements, with new devices being constantly developed and upgraded. This section provides a brief introduction to some of the more common tools.

When installing or using ROV tools, all relevant manufacturer and industry safety instructions should be applied. Just as with any other piece of equipment, an appropriate maintenance log should be preserved. When operating ROV s in areas where considerable current or surge may be present, planning and assessment techniques should be employed to ensure that the mounted tools will not create a hazard to either the personnel or the vehicle.

**Cameras.** Cameras can be mounted in a fixed position, on a pan-and-tilt assembly, or held by a manipulator. Video systems with the ability to view in conditions of low-light intensity and still cameras to furnish high-resolution documentation are available. Pan-and-tilt assemblies furnish a capability to allow training of the camera system to permit omnidirectional viewing.

**NDT Sensors.** The more commonly used sensors for NDT activity are cathodic potential (CP) probes, ultrasonic thickness measurement devices, and flooded member detection systems.

**Acoustic and tracking.** Numerous acoustic systems are available, such as tracking and measurement devices, scanning, profiling, side-scan, sub-bottom profiling, bathymetric and pipe tracking.

**Cleaning.** ROVs can be used as a platform for cleaning devices used for structures and/or vessels. These devices can range from simple rotary wire or nylon brush systems to more sophisticated units capable of removing calciferous marine growth.

**Station-Keeping.** Many ROVs are capable of maintaining heading, depth, and position. Attachment devices are available to permit the ROV to be located in a virtually fixed location. Some of these devices are:

a. Docking cones and similar stabbing devices.
b. Suction pads and water pumps for hydrostatic attachment on smooth surfaces.
c. Manipulator-mounted hydraulic devices to grip structural members.

**Scientific Tooling.** All classes of ROVs can be employed for performing scientific operations with specialized tooling and accessories. Benthic sampling, ecosystem intervention, and other science-related activities are performed using ROVs.

**Work Tooling.** This category covers a vast range of tools from simple bars, hooks, and knives to sophisticated single-purpose tools, such as anode installation packages, through to specially designed multi-mode tools. The most common work tool is the manipulator which can be used alone or in association with other tools. Tools that can be operated by the manipulator without additional power are known as 'hand tools'. However, the majority of tools require either hydraulic or electrical power.

### 9.2.4 ENVIRONMENTAL CONSIDERATIONS

To ensure the safety and efficiency of the intended operation, it is necessary to take into consideration both the probable and unanticipated environmental considerations of the intended work site.

ROVs can operate anywhere from very shallow locations to depths in excess of several thousand meters. Increased depth capabilities are being achieved as the need develops for the conduct of deeper operations. Individual ROVs should not be used below their design depth. When operating ROVs, consideration should be given to:

- Umbilical length and associated drag. These influence the specification of the topside handling system.
- Temperature. Extreme temperatures (both high and low) may affect the reliability of electronics and cause a material fracture that leads to structural or mechanical damage, particularly in arctic conditions. Hydraulic oil and lubricants that offer stable properties over the intended temperature range should always be used.
- Variations in temperature, salinity, depth, and acoustic noise should be considered for their possible adverse effects on acoustic tracking and positioning systems.

Water characteristics may also have an effect. The following factors should be taken into account when assessing the use of a vehicle for a given task:

- Visibility. Poor visibility can adversely affect an operation and may require the use of sophisticated equipment, such as acoustic imaging systems. Vehicle operation near the seabed may stir up fine-grained sediment that remains in suspension to reduce visibility in low- or zero-current conditions.
- Temperature. Extreme temperatures (both high and low) may affect the reliability of electronics and cause a material fracture that leads to structural or mechanical damage, particularly in arctic conditions. Hydraulic oil and lubricants that offer stable properties over the intended temperature range should always be used.
- Salinity. alinity. This may vary substantially near river mouths, in tidal estuaries, and near outfalls. The resulting variation in water density may affect ROV buoyancy, trim, and the accuracy of sonar data.
- Pollutants. ollutants. The presence of petroleum products or other pollutants can cloud optical lenses, damage plastic materials, affect visibility, block sound transmission or cause a sudden loss of buoyancy. Where pollutants are present, precautions should be taken to protect the in-water portions of vehicles and the topside personnel who handle the ROV during launch, recovery and maintenance.
- Water movement. ROVs are sensitive to water movement, and extra care should be taken in shallow water where surge or thrust from surrounding vessel propellers or thrusters can have an effect on vehicle control.

Currents can create considerable problems in ROV operations, but quantitative data on particular current profiles are rarely available.

Simulations and analysis can provide good current prediction, but currents do not remain constant for long, even those close to the seabed. Currents also vary with location, and surface currents can be rapidly affected by wind. Tidal meters and historical data are useful indicators of current strength and direction for particular areas and depths..

Factors that may affect ROV operations, including their maneuverability in current, include:

- Length and diameter (mass) of umbilical.
- Propulsion power.
- Depth and orientation to the direction of the current – a non-uniform current profile.
- Umbilical “strumming” or “spinning” in deep water (this may require the use of specially designed umbilicals).
- Vehicle hydrodynamics (i.e., surface area and profile).
- Sea state and swell can affect every stage of an ROV operation.

Safety must always be carefully considered when launching or recovering an ROV, particularly from a support vessel in rough seas. ROV operators should understand the effect of a heaving support ship on the umbilical attached to a relatively motionless ROV and should be aware that the ROV handling system can be overloaded or that personnel on deck may be exposed to a risk of an accident.

In rough conditions, personnel involved with launch and recovery must wear all necessary personal protective equipment and fully understand their own role as well as the roles of others involved in the operation. Good communication is vital for avoiding accidentsds.

In certain situations, deployment systems incorporating motion compensation can either reduce or better accommodate the effect of wave action and thereby permit ROV operations to be conducted in higher-than-normal sea states while maintaining high safety standards.

While ROVs themselves are not normally sensitive to weather, the cost and efficiency of ROV operations can be affected by the weather in a number of ways:

- Wind speed and direction can make station-keeping difficult for the support vessel and adversely affect ROV deployment and recovery.
- Rain and fog can reduce surface visibility and create a hazard for the support vessell.
- Adverse combinations of wind, rain, snow, etc., can make the work of ROV crews hazardous for personnel on deck
- Hot weather can affect ROV electronics and related systems. Likewise, hot weather can have an adverse effect on ROV crew personnel on deck.

Operations should therefore be carefully monitored with regard to the safety of both personnel and equipment affected by adverse weather conditions.

Additionally, seabed characteristics and topography should be known in advance. Rocky outcroppings or submerged structures can make a collision more likely and add to the risk of abrasion of the vehicle umbilical, or affect signal transmission from sonar or other devices.

### 9.2.5 OPERATIONAL CONSIDERATIONS

In order to assure the safe and efficient use of ROVs, operators should ensure that the chosen ROV system has been satisfactorily tested prior to use and that it is capable of meeting the operational requirements of the job. The ROV supervisor should commence an operation only after carefully considering:

- System and crew readiness.
- The effects of environmental factors anticipated during the operation.
- Potential risk factors that may be present during the operation.
- The nature and urgency of the intended tasks.

All of these plus a variety of other considerations must be made a part of the job hazard analysis conducted during planning and aassessment. These include:

- **Operating procedures.** The operating procedures shall consist, as a minimum, of the ROV contractor's safe practices/ operations manual ( company procedures) together with any site-specific requirements and procedures. Contingency procedures for emergency action are also a requirement. The management chain of command for an ROV project shall be clearly defined, and the ROV supervisor shall be identified in writing. If operations will continue beyond a single shift per day, an alternate ROV supervisor must be designated.
- **Planning and assessment.** Specific operating procedures necessary for accomplishment of the intended tasks will be largely determined during the planning process. This process is intended to analyze potential hazards, areas of possible job interference and an assessment of other risks as may be deemed to be possible during the conduct of operations.
- **ROV systems' location and integrity.** During the planning and assessment phase, consideration must be given to the site from which the ROV operations will be conducted. Dependent upon the project, this may be from an offshore platform, vessel, pier, shoreline, small boat or another site.

Additional, considerations that must be factored into the operational plan include, but are not limited to:

- The type of structure or vessel from which the ROV operations will be conducted and an evaluation of whether there is sufficient working area for the ROV, its associated systems and the ROV crew members.
- Whether the dive control station is in an area of hazard, such as where ignition of gas, vapor or liquid could cause a fire or explosion.
- Whether surrounding or associated operations can create a hazard either to the ROV, its systems or crew personnel. Examples of this might be where crane or other associated overhead operations are being conducted.
- The proximity of the ROV to a required handling system with consideration of lateral or horizontal distances that must be traversed in order to launch or fully recover the vehicle.
- Handling systems, whether for ROVs or other uses, can be inherently dangerous if care and attention during their use is not maintained.

Detailed operating procedures for each handling system should be readily available at the job site, and ROV operators must be knowledgeable regarding the safe working loads to which that system is limited. When the system is to be secured to a deck by a welding process, non-destructive examination methods should be employed to ensure the appropriate integrity of the installation.

- Testing and periodic examination. A procedure should be developed for a responsible person to examine ROV handling systems:
- At least every six months for physical damage, misalignment or evidence of wear at critical points.

- After any major alteration or repair that may affect its integrity.
- After having been relocated from one position or site to another.
- Cables, umbilicals and associated hardware should be examined at least every six months in accordance with the manufacturer's recommendations and any such regulatory guidance in effect. Appropriate log books and records should be maintained..
- Communications. Effective and reliable communications are critical to the safety and success of any operation. All personnel involved in the operation shall be fully aware of the work being undertaken and the status of any unusual situation that may or does arise during the work performed.
- Diving operations. The diving supervisor has ultimate responsibility for the safety of the entire operation when diving operations are taking place. Communication must be maintained at all times between the diving supervisor and the ROV supervisor. Refer to Section 9.3 for ROV diver operations.
- Vessel control. The ROV supervisor shall ensure and maintain effective communication with vessel movement control personnel whenever ROV operations are in progress.
- ROV operating sites. ROVs are required to operate from different locations with varying levels of support for the ROV system and crew. Due consideration should be given to the limitations of each location on safety and efficiency. Suitable deck strength, extra supports, external supplies and ease of launch and recovery should be considered.

Prior to mobilization, the ROV supervisor should inspect the site and decide on the optimum location for the ROV system. Umbilical or cable runs should be carefully established to protect against physical damage or interference. Additionally, the length and fleet angles for these runs must be evaluated to protect system integrity and functionality.

When considering the use of vessels of convenience for support of ROV operations, operational limitations may be encountered. Some of these limitations may relate to:

- Lack of maneuverability.
- Lack of navigational accuracy.
- Mooring or anchoring systems.
- Deck space.
- Electrical power reserves.
- Propeller guards.
- Limited personnel accommodations.
- Familiarity with intended type of operations.
- Minimal (or excessive) freeboard.

When intending to conduct operations from a fixed platform, there are a number of specific areas of consideration, such as:

- A need to comply with specific, often onerous, zoning requirements relating to hydrocarbon safety, or other specific regulations of the operator.
- Difficulties of installing surface support equipment.
- Training requirements for ROV crew personnel related to platform-oriented operations.
- Deployment and recovery complications (including tidal effects) caused by the height difference between the platform deck and waterline.
- Hazards created by surrounding activities on the structure.

This can include anchored, moored, or DP vessel operating sites that present similar hazards as those of the fixed platform variety, although zoning and hydrocarbon safety requirements will normally apply only to drilling rigs. Where DP vessels are to be utilized, it must be remembered that the vessel propellers/thrusters are in constant use. Care must be assured that the ROV umbilical does not come into incidence with rotating equipment and that the umbilical will not be adversely affected by thrust or wash from same.

- **Navigation.** The use of acoustic location beacons on some ROVs contribute to navigation, positioning, and tracking. In some cases, an ROV can be placed beside a submerged object to establish an accurate position for that object. In some situations, there is a potential danger of acoustic interference, such as shadowing or noise, if several vessels are operating in the same area or if large-scale construction or survey projects are present. This can be a particular problem if the DP vessel relies on acoustic signals for positioning. Frequencies for acoustic beacons should be selected to avoid interference. In larger projects, these tasks of coordination of frequencies employed may necessitate some form of central control.
- **Manuals and documentation.** To ensure the safe and efficient operation of ROVs, appropriate log books, checklists and manuals are required on-site. It is the contractor's responsibility to ensure that each ROV supervisor is supplied with the necessary documentation. Regulations and legislation appropriate to the intended area of operations must also be understood and available at the site of operations.

- **Umbilicals.** Umbilicals can be broadly categorized by their weight and material composition, but they vary in strength, power and signal transmission characteristics. It is important to consider the changes in buoyancy of the umbilical when the ROV is operating in both freshwater and seawater environments.
  - Lightweight umbilicals are generally reinforced with Kevlar for strength, and use some form of appropriate abrasion-resistant material for jacketing.
  - Medium-weight umbilicals may comprise a jack, a stainless-steel braid and a Kevlar® central member.
  - Heavy-weight, or armored, umbilicals can be used for lifting.

ROV supervisors and operators should be aware that the umbilical is limited by its breaking load, safe working load and minimum bend radius. Periodic and routine inspection and maintenance of umbilicals should be performed in accordance with the manufacturer's design and instructions, and re-termination should be performed as per those instructions.

- **Launch and recovery.** The ROV supervisor is responsible to ensure that a safe launch and recovery of the ROV can be performed and that all members of the ROV and support crew understand what is required. These evolutions should progress in a smooth and logical manner with all personnel involved fully aware of the situation at all times. The ROV handling system's design parameters should furnish calculations to define launch and recovery limitations based on weather, sea state, support vessel motion, and other parameters appropriate to the intended operation.

In addition to those discussed above, a number of other physical hazards may be encountered during ROV operations. These include:

- Intakes/discharges. ROVs are vulnerable to suction or turbulence caused by water intakes and discharges. The ROV supervisor should establish the presence of any such intake and discharge locations that may create a hazard and establish procedures to minimize their effect.
- Diving operations. When conducting ROV operations in the vicinity of diving operations, certain hazards are introduced, such as possible entanglement of umbilicals, physical contact, electrical hazards and the fact that ROV propellers or thrusters can present a hazard. Close liaison between the ROV and diving supervisors is required.
- The physical hazards to divers caused by the power, mass and possible inertia of the ROV should not be underestimated.
- Communication between the ROV and diving supervisors must be effective and continuous and is mandatory. A loss of this communication requires emergency procedures and an immediate stop of the ROV propellers/thrusters/tracks.
- ROV electrical requirements are significant and able to create hazardous situations if not properly handled. Care must be taken to ensure that all personnel are protected from any electrical hazards at all times, whether during maintenance, pre-launch, post-launch or operational conditions.
- Some ROVs carry high-pressure water-blasting equipment. These systems have been known to cause accidents and fatalities and severe damage to equipment when not used correctly. Care must be taken during testing and operation to prevent accidents both during topside and in-water activity.

### 9.2.6 PERSONNEL

All ROV personnel should be competent to carry out the tasks required of them. The qualifications of ROV personnel are determined by training, experience and actual evaluations of the individual by the employer.

Safety of personnel is paramount during operations and maintenance; it is the responsibility of the contractor to provide a skilled team of sufficient numbers to ensure safety at all times. When defining the team size, the contractor should consider:

- Nature of the work being undertaken.
- Deployment method.
- Location.
- Vehicle classification.
- Operational period.
- Ability to respond to emergency requirements.

The contractor should provide a sufficient number of properly trained and experienced personnel, able to operate all equipment and provide support functions to the ROV team. For safe operations, the team may also need to include additional deck support personnel and other management or technical support personnel. However, personnel not normally employed by the ROV contractor (e.g. clients, vessel crews, etc.) can create a hazard to themselves and others if they lack familiarity with the contractor's procedures, rules, and equipment. Therefore, their competence and suitability should be carefully considered before their inclusion in the ROV team.

Safe working practice dictates that personnel should not work alone when dealing with:

- High voltage.
- Heavy lifts.
- High-pressure machinery.
- Umbilical testing.
- Potential fire hazards (welding, burning, etc.).
- Chemicals capable of generating toxic fumes.

# 9.3 ROV AND DIVER OPERATIONAL PROCEDURES

## 9.3.1 INTRODUCTION

These recommended guidelines and procedures have been written to cover general guidelines regarding ROV-diver operations. These procedures are intended as guidelines for supervisors and operators.

The essential factor to successfully and effectively conducting simultaneous ROV operations with diver intervention is **COMMUNICATION.** This word will be used often in these procedures. A clear line of communication between ROV crews and dive control is critical.

**A job safety analysis is a critical ingredient to assuring that all factors necessary to support the highest levels of safety have been considered.**

## 9.3.2 DEFINITIONS

**ROV** Remote Operated Vehicle

**TMS** Tether Management System

**LARS** Launch and Recovery System

**HPU** Hydraulic Power Unit

**FSW** Feet Sea Water

**MSW** Meter Sea Water

## 9.3.3 ROV AND DIVE TEAM OPERATIONAL PROCEDURES

**COMMUNICATIONS ARE KEY TO SAFE AND EFFICIENT OPERATIONS.**

### 9.3.3.1 PRE-DIVES

In addition to standard pre-dive briefings:

- It is important that all divers and dive supervisors are familiar with all aspects of the ROV.
- Location of thrusters, diver toolbox, manipulator arms, tether and camera locations should be areas of focus during this orientation.
- Camera location is important in order to emphasize to diving personnel the pilot's field of vision.
- Tether is not to be used as a crossover/swim line for divers.
- When mounting a diver toolbox on ROV, place it in a location that takes into consideration that most diving tools have lanyards on them. The diver needs to be able to access the toolbox and tools without getting lanyards or the divers themselves fouled in thrusters.
- Thruster location is important to divers. Divers will have pneumos and tooling with lanyards. Even with thrusters nulled and the pilot holding a dead stick, thrusters will rotate. Divers need to secure all lanyards and pneumo hoses before approaching an ROV.

### 9.3.3.2 SUBSEA OPERATIONS

Before the ROV approaches a diver, the diving supervisor must be notified. Slow, easy movements of the ROV are required to prevent injury to the diver. When the diver approaches the ROV, the diving supervisor must be notified as well as the ROV supervisor or pilot. The ROV should stop all movements in order to allow the diver to approach. When possible, the diver should approach from the front of the ROV, to allow the ROV pilot to view him or her. If the ROV needs to dial in vertical thrust down, in order to hold position, the pilot should notify the dive supervisor that the thrusters are operating during the diver's approach.

Using manipulators with divers:

- The ROV should place the manipulator in such a position that diver can place a tool in the jaws.
- The ROV pilot should then inform the diving supervisor that the manipulator jaw is closing. Once this is acknowledged, only then should the pilot close the ROV jaws.

- The ROV should never try to take a tool from the diver; the diver must place the tool in the manipulator's jaws to minimize the manipulator movements.
  - The ROV tether should never be used for a diver crossover/swim-line.
  - When establishing a swim line for a diver:
- After the ROV has acquired the hook for the crossover line, the diver should pay out the crossover line as the ROV flies to the connection point.
- The diver should not let out excessive amounts of line during this operation. Line should be kept taut; if the pilot requires additional slack, he or she can then notify the dive supervisor.
- After the crossover line is established, the diver should secure it so that excessive slack is not floating about for ROV to get tangled in thrusters.
  - Tag lines should be cut short or made ROV-friendly from the surface. ROV-friendly tag lines are ones that are removable from the surface, after tag lines have served their purpose, in over-boarding equipment. If the diver is required to cut tag lines, the pieces cut off should be tied to a retrieval shackle, on the down line cut-off pieces should then be recovered to the surface for disposal, to mitigate the possibility of fouling ROV thrusters with rope floating about subsea.
  - As stated earlier, the diver should not use the tether as a crossover line. The diver should also try to go under the ROV tether.
  - This will help prevent any entanglement problems with the diver, should the ROV lose hydraulics.

If the ROV is in a no-visibility situation:

- The diver should return to the stage or bell if the ROV needs to perform tasks. If the ROV is not needed and the diver is required to stay on location, the ROV should go dead stick. The pilot should then inform the dive supervisor that the ROV is in a no-visibility situation and should remain clear from the diver. The ROV pilot should allow the ROV to rise above no-visibility to an area where visibility can be obtained. The ROV should not, for any reason, be flying in a no-visibility situation with a diver in the area.
- The ROV pilot should be aware of all lines in the water. There will usually be at least one down line, running from the surface to the diver's work location. Additionally, one or more crossover lines will also be present. This crossover line will run from the stage or bell (when applicable) to the work location.

### 9.3.3.3 ROV AND DIVER INTERVENTION

- During multi-ROV/multi-diver operations, the ROV should answer to the designated call sign of that system, (e.g., XL19, XL16, Quest, etc). No generic "ROV" communication should be used over radio.
- Dive teams should be referred to as designated teams (e.g., shallow team, deep team, manifold team, etc.).
- It is recommended that dive teams be divided/assigned to particular ROVs.

When assigning ROVs/divers, the following will be taken into consideration:

- Launch point of ROV.
- Deployment point of dive teams.
- Task at hand.
- Routing of ROV tethers and diver umbilical.

The field of operations should be assigned to each ROV/dive team. The ROVs should then work within these areas during operations. If at any time, the ROV is required to leave the established fields of operation, both the ROV and diving supervisors should be notified, to make necessary changes. Both supervisors should ensure all dive and ROV members are aware of any ROV entering designated work area.

- All communications over the radio should be acknowledged and repeated for verification, prior to any task being carried out.

### 9.3.3.4 SURFACE NAVIGATION SAFETY CREW

The survey (tracking of the ROV) should, in certain instances, be handled by a third-party contractor. In this case, the ROV crews should have to rely upon the survey crew extensively during the course of any multi-ROV operation. Good, clear communication is critical between these two crews. The following recommended guidelines will cover some of the steps that should be established for the successful interface between the two crews.

- The ROV crews should run video and communication lines between the ROV control vans and the survey control van. The two crews should be in constant communication during any and all dives.
- The survey crew should run computer video lines to the ROV control vans and place a monitor in each ROV control van to provide tracking information. The screen on the navigation monitor should display the surface support vessel, the ROV, and any subsea structures in the area, etc. This should assist the ROV pilots in navigating the ROV to, from, and around the scope of operation.

The tracking of the ROV is established by the use of the following equipment:

- ROVs should be tracked by using the LBL or USBL modes. In the LBL mode, the ROV should have a mini ROV NAV system installed. If in USBL mode, the ROV should have a mini beacon installed.
- A navigation monitor should also be placed in the bridge of the surface support vessel. This should enable the captain of the vessel to track the ROV's movements and keep the surface vessel in the desired position during ROV operations.

### 9.3.4 PRE-DIVE PROCEDURE

1. Verify sea state conditions are safe to dive.
2. Inform client representative, survey and vessel captain of intent to dive.
3. Verify all cables are secured and clear from entanglement.
4. Verify all static compensators are full and bled of air (if applicable).
5. Verify all hydraulic compensators are full and bled of air (if applicable).
6. Inspect system cursor (if applicable).
7. Verify ground strap is attached (if applicable).
8. Verify good communications from control van to winch/LARS area.
9. Verify with other ROVs the intent to conduct deck checks.
10. Turn on power to TMS; verify TMS hydraulic pressure (if applicable), communications (if applicable), and that current draw is not excessive.
11. Calibrate pan-and-tilt system. (If applicable)
12. Verify TMS tether-in and tether-out functions properly.
13. Verify TMS latch and unlatch functions properly (if applicable).
14. Turn off power to TMS HPU (if applicable).
15. Turn on instrument power; verify telemetry indicators are good (if applicable).
16. Ensure that the gyro is operational and in the slave setting (if applicable).
17. Verify all GFD values are at acceptable values.
18. Turn on all cameras; verify quality video is received, test-operate all VCRs and re-install SIT cover.
19. Enable light power; verify all lights are variably controlled through controls (if applicable).
20. Turn on sonar power; verify that sonar passes self-test and telemetry is established.
21. Turn on altimeter power and verify reading.
22. Turn on power to "function" manipulator and verify valid telemetry.
23. Verify all personnel are clear of ROV area.
24. Turn on ROV HPU (if applicable, verify that hydraulic pressure and current draw are not excessive).
25. Test any and all ancillary tooling, with client representative in attendance, if required.
26. Turn on all survey and tracking devices.
27. Verify proper pressures on compensators and system pressure gauges (if applicable).
28. Verify clearance of operation and speed of pan-and-tilt units.
29. Verify the proper operation and speed of the manipulator.
30. Verify proper rotation of thrusters and that no excessive noise is heard.
31. Shut down HPU (if applicable).
32. Turn on RF beacon and test the receiver (if applicable).

33. Turn on the emergency flasher (if applicable).
34. Remove SIT camera cover (if applicable).
35. Remove ground strap (if applicable).
36. Launch ROV.
37. Enter launch time, dive number and task in operations log book.

### 9.3.5 POST-DIVE PROCEDURE

1. Turn off power and attach ground strap to the ROV (if applicable).
2. Install all camera covers. (It is very important to ensure the SIT camera cover is installed.)
3. Turn off emergency flasher (if applicable).
4. Turn off emergency RF beacon (if applicable).
5. Wash down system with fresh water (if applicable).
6. Visually inspect ROV and TMS for damage and debris.
7. Inspect thrusters for damage, debris or excessive wear.
8. Check and fill all compensators and bleed off air (if applicable).
9. Inspect umbilicals for signs of wear.

### 9.3.6 MULTI-ROV OPERATIONAL PROCEDURES

This section describes the recommended actions necessary to safely deploy multiple ROV systems for operations. It will also address the personnel and equipment safety issues associated with deploying the ROV systems.

**The steps presented in the pre-dive checklist must be completed before an ROV system can be deployed.**

- Once all pre-dive checks are completed and the hydrophone pole is deployed (if applicable), all personnel shall man their assigned duty stations. The ROV supervisors should conduct a brief tasking meeting. At this time, it should be decided which ROV will be the primary (or lead) of the dive. The primary ROV shall have right of way over other ROVs in that theater of operations.
- The ROV superintendent should inform the captain of the vessel of intent to dive.

**NOTE:** It is recommended that only one ROV is launched at a time. Before any functions are conducted that would cause any substantial power draw, the pilot of that ROV is to inform the other ROV of his or her intentions.

- The lead ROV pilot shall man the ROV consoles in the control van.
- The lead ROV co-pilot shall man the winch.
- The lead ROV supervisor shall be the LARS observer and relay information to the winch operator.
- The ROV pilot shall verify with the captain of the vessel that the captain will maintain a heading that puts the vessel bow into the seas if practical, which should reduce any rocking motion of the vessel.
- The LARS observer shall make sure all non-essential personnel remain clear of the launch area.
- On the ROV pilot's command, the winch operator should boom the LARS A-frame over the side of the vessel. The winch operator must make sure that no tension is put on the umbilical during this maneuver.
- When the A-frame is at its full limit, over the side of the vessel, the slack should be taken out of the umbilical and slight tension put on it.
- The LARS observer should be watching the seas and swells and set the timing for the winch operator to lower the ROV system.
- At the LARS observer's command, the winch operator should tension up (low tension) the umbilical to compress the shock absorbers on the swing frame approximately 3/4 of their stroke, then open the swing frame latches and begin to lower the ROV system.
- Due to the extreme forces exerted upon the ROV system while traversing the interface zone, the winch operator must rely upon the LARS observer to set his or her timing for lowering the ROV system (through the interface zone). Once the ROV system is successfully deployed through the interface zone, the LARS observer will return to the control van and assume the responsibilities of supervising the overall operation.
- When the ROV system is approximately 50 feet below the surface, the ROV pilot should give the winch operator the command to all stop. This should allow the ROV pilot to turn on the TMS and ROV HPUs and the winch operator to change the winch to high tension (if applicable).
- Once the HPUs have been turned on, the ROV pilot should give the winch operator the command to continue down to a safe standby depth 200 fsw.

- At this time, the secondary ROV will perform the above-mentioned steps for launch.
- Once the secondary ROV has made it through the interface zone and has hydraulics up, the OK can be given to the lead ROV to continue descent.
- If a third or subsequent ROV is to be deployed, the above steps should be carried out for each ROV.
- During the descent of the ROV systems, all ROVs should continually monitor the attitude and distance of the other ROV's umbilical.
- This is to prevent any entanglement of the umbilicals during ROV descent. This can be done using the ROV's sonar.
- During the descent of the ROV systems, the winch operator must be aware of the umbilical and watch for snap-loading it, due to the rocking of the support vessel. If this occurs snap-loading may be lessened by not paying out umbilical when the vessel rocks towards the launch side of the vessel.
- The lead ROV system should be stopped approximately 50 feet above the work site.
- The secondary ROV should be stopped at 70 feet above the work site and subsequent systems at ascending intervals.
- Upon reaching working depth, the ROV pilots should give the command for the winch operator to "all stop on the winch." At this time, the winch operator should stop paying out umbilical, ensure that the winch brake is set, and turn the winch HPU off. After the winch HPU is turned off, the winch operator shall go into the control van and assume the responsibilities as co-pilot.
- Once the ROV system has been stopped at the proper working depth, the ROV pilot shall monitor the depth display to determine if there is any heaving of the system due to the rocking of the support vessel. If the system is heaving up and down, the pilot should monitor the heaving action, set his or her timing and wait for a lull. When there is a lull in the heaving that the pilot has determined will last long enough, he or she should disengage the ROV from the TMS.
- Upon determining that the timing is right to disengage the ROV, the pilot will give the ROV a little up thrust command, tether out on the TMS and open the TMS latches. Once the latch indicator indicates that the TMS latches are open, the ROV pilot will change the vertical thrust command from a little up to medium down while continuing the tether out command on the TMS.
- Upon successfully separating the TMS and ROV, the pilot may proceed to the work site while continuing to pay out tether from the TMS. The tether should be kept snug but not tight.
- All subsequent ROVs may deploy to their respective work sites after the lead ROV has established itself to its work site. Note that before departing the TMS, a confirmation must be obtained from the other ROVs currently at their work sites.
- Extreme care and constant monitoring of the work areas is to be maintained, as there may be a number of umbilicals, wire ropes, sonar reflectors/buoys and crane wires in the water at the same time. Never fly blind from one area to another, including returning to the TMS. Always inform the other ROV systems of your intent and when you have completed your move.

### 9.3.6.1 SYSTEM RECOVERY

This section will describe the actions necessary to safely recover an ROV system from operations. It will also address the personnel and equipment safety issues associated with recovering an ROV system.

- Upon making the decision to return to the TMS for recovery to the surface, the ROV pilot must first ensure that the vehicle and the tether are free of any obstructions.
- Once the vehicle and the tether are free of any obstructions, the ROV pilot should put the joystick commands in the reverse position.
- The pilot may then use the rear-facing camera to fly back to the TMS, keeping the tether in view at all times.
- While flying back to the TMS, the pilot must make sure to clear the tether of any obstacles and keep enough slack in the tether to compensate for any heaving action that may be acting upon the TMS.
- The ROV pilot must make sure to take any turns out of the tether prior to docking the ROV and TMS together.
- The pilot must ensure that he or she is bringing the ROV back to the TMS at a depth that would have the ROV approaching the TMS at least 10 to 20 feet below the TMS. Whenever possible, the ROV should not be tethered back in to the TMS at a depth above that of the TMS.
- Upon visually seeing the TMS in the rear-facing camera, the pilot should start judging the amount of heave action acting upon the TMS, if any, and start determining the timing for latching the ROV back into the TMS.
- As the pilot is determining the timing for re-entry into the TMS, he or she should ensure that the TMS latches are open.
- Once the pilot has determined the timing, he or she should then position the ROV directly under the TMS and orient the ROV to the compass heading the ROV was on at the time the ROV was deployed from the TMS. Then, the pilot should bring in the remaining tether while exerting a small amount of down thrust. The pilot must then fly the lifting bail of the ROV into the docking guide of the TMS.

- When the lifting bail of the ROV is in the docking guide of the TMS, the pilot should look to see if the fail-safe latch indicator is on. If the fail-safe latch indicator is on, the pilot should then apply a half up thrust command, tether in, and close the TMS main latches. The pilot should then look to see if the latch indicator is on. If the latch indicator is on, it is safe to start the ascent of the ROV system to the surface. If the fail-safe or main latch indicators do not come on, the pilot must give the ROV a vertical down command and tether out, then fly the ROV down and away from the TMS. Then determine what caused the failed latch attempt and try again.
- When the ROV pilot has successfully latched the TMS and ROV together, he or she should give the winch operator the command to bring the system to the surface and inform the vessel captain that the ROV is back in the TMS.
- The winch operator must make sure all non-essential personnel are clear of the area.
- The winch operator must make sure that the winch brake releases and begin to bring in the ROV system.
- The ROV pilot should periodically communicate to the winch operator the depth of the ROV.
- The ROV supervisor should report to the LARS skid to serve as the LARS observer and assist the winch operator with the recovery of the ROV system.
- When the ROV pilot reports to the winch operator that the ROV system has reached 100 fsw, the winch operator should stop the ascent of the ROV system and switch to low tension (if applicable), then continue the ascent at approximately 30 feet per minute. The winch operator must rely upon the LARS observer to establish the timing to retrieve the ROV system through the interface zone.
- As the winch operator retrieves the ROV system from the interface zone, he or she must slowly winch in the ROV system until it comes into contact with the swing frame. Upon initial contact with the swing frame, the damping ring should counteract any swinging of the ROV system.
- When the swinging of the ROV system has subsided, the winch operator should winch in slowly until the shock absorbers on the swing frame have compressed approximately 3/4 of their stroke, and then close the latches on the swing frame until the latch indicators disappear.
- When the latches have been closed, the winch operator should slowly pay out enough umbilical to take the tension off of the umbilical.
- The winch operator should then begin to boom the ROV system inboard while manipulating the swing frame in order to keep the ROV system level.
- The winch operator should continue to boom the ROV system inboard until the ROV system sets down onto the LARS skid. Post-dive checks should then take place.
- Inform the captain of the vessel, survey and client representative that the ROV is back on deck.
- Ensure hydrophone pole is up (if applicable).

### 9.3.6.2 DATA COLLECTION

**The following are only recommended guidelines for data collection.**

Data collection is a very important aspect of any ROV operation. The actual work that is to be done is only half of the operation, and the job is not complete without the concise and orderly collection of the pertinent data.

This section will detail the necessary steps and procedures required for the systematic and orderly collection of data encountered during an ROV operation.

**Video Recording**

It is recommended that all contractor ROV system control vans be outfitted with a minimum of two video recorders. One should be designated as the job footage recorder and the other one as the “black box” recorder.

**Black Box**

The ADCI recommends, when possible, that a black box recorder be available. It is also recommended the black box video recorder is in the record mode at all times during any ROV operation. Like the black box recorder on any aircraft, it records continuously during the operation. This is done so that if something goes wrong, the event will be captured on the video. Because of the use and nature of the black box recorder, the following guidelines shall be used:

- The black box recorder will be labeled “black box.”
- The black box recorder will be turned on prior to any dive and left on until the system is back on deck.
- When the black box DVR reaches maximum storage, and there is no information recorded that needs to be saved, the DVR can be erased and recorded over. It is suggested that sufficient DVR storage be available, allowing 12 consecutive hours of operations to be recorded before previous operations are archived, erased or recorded over.

### 9.3.7 EMERGENY VEHICLE RECOVERY PROCEDURE

The following is to serve as recommended general guidelines for emergency recovery procedures while operating onboard the vessel.

This is only a reference document, and all decisions concerning ROV equipment and ROV personnel will be made by the ROV supervisor on site. For individual system procedures, please refer to that system's emergency recovery procedures. Various determining factors will include, but not be limited to, weather conditions, sea state, current conditions, navigation, vehicle status and vessel status. A pre-job meeting will be held with the ROV crew, vessel personnel and client representatives. All pertinent personnel arriving after the beginning of job shall also be briefed. In case of one or more of the following events occurring, the primary consideration is, and shall always be, personnel safety.

### 9.3.7.1 VEHICLE HPU FAILURE

Vehicle HPU failure will normally be indicated by a hard fault to ground on the HPU ground fault detector causing a GFI on the HPU breaker. Telemetry and video should still be operational and should aid in a successful recovery.

- The ROV supervisor should inform all pertinent personnel on the vessel of situation.
- If live boating, the ROV pilot should inform the captain to hold the vessel steady and into the seas. If the vessel is tied up to another vessel or structure, the pilot should inform the captain of the situation and to stand by for immediate response.
- If the ROV vessel is positively buoyant, the pilot should have the winch operator begin to slowly raise the TMS while the pilot tethers in. If, for some reason, the vehicle is negative or descending very slowly, the pilot can tether in immediately. Before attempting to dock into the TMS, the winch operator should slowly lower the TMS to assist in latching the vehicle.
- Once the ROV is in the TMS with visual verification and the TMS caged light is illuminated, the winch operator should lower the TMS and the pilot should toggle the TMS latch switch.
- The vehicle can now be recovered following normal operating procedures.
- Once the vehicle is on deck, repairs should begin.

### 9.3.7.2 VEHICLE INSTRUMENTATION FAILURE

- If telemetry is lost to the vehicle, the vehicle should continue to have video signals and HPU controls should automatically enter fail-safe mode. In fail-safe mode, the vehicle should automatically zero all horizontal thruster controls and enter auto depth mode to maintain depth when the telemetry signal was lost. This should aid in latching the ROV into the TMS and normal recovery thereafter.
- If loss of all instrumentation occurs, HPU and instrument breakers should be shut down if they have not already tripped.
- Recover ROV as per HPU failure.

### 9.3.7.3 TETHER SEPARATION

- If there are indications that the tether has been separated (no latch indication, tether counter continues far past zero), the TMS should be shut down and raised to the surface.
- The ROV supervisor should alert the captain and appoint lookouts at posts around the vessel.
- The ROV supervisor should confer with survey personnel and the captain to track the ROV if still receiving survey transponder beacon signal from the ROV. The captain should keep vessel within 100 feet of the vehicle during its ascent. If the vessel were tied to a structure, the ROV supervisor should inform the captain to untie the vessel from the structure as soon as the TMS is recovered to surface.
- If no signal is being received from transponder beacon, the ROV supervisor should have surveyors raise hydrophone pole.
- If survey information indicates the vehicle transponder is functional and the vehicle is not ascending, survey should take fix on the ROV's location, and the captain should get GPS coordinates. The ROV contractor's office should be informed immediately and personnel on the vessel wait for further instructionss.
- If survey information indicates the vehicle was ascending and loses signal at shallow depths (out of hydrophone operational cone), lookouts should be alerted and an RF beacon locator used to track the ROV.
- Once the ROV is located on the surface, the vessel should position itself so that the ROV is on the starboard mid-section of vessel (recovery zone). The ROV crew should place a recovery sling onto the ROV. At this point, the crane on the vessel's starboard side should be used to recover the ROV and place it back onto the LARS frame.
- Recovery personnel should be outfitted with life vests and should attempt to hook the vehicle at the lifting bell, if possible.
- Depending on where the tether parted, using choker slings, or even using the tether itself, may aid in recovery.
- Once the vehicle is on deck, ROV crew should secure the ROV to the LARS.
- The ROV contractor's office should be informed immediately.
- The crew should begin tether replacement and any other repairs required.

### 9.3.7.4 TMS FAILURE

- If indications arise that the TMS is no longer operational, the ROV supervisor should inform the vessel captain immediately. If the vessel is anchored to a structure, the captain should stand by for immediate response and alert other vessels in the area to stay clear.

- If the vessel is live-boating, the captain should slowly begin moving the vessel to a clear area while the ROV pilot follows the vessel, to ensure the tether is clear.
- If possible, the captain should put the vessel screws in neutral until the tether is secured. If this is not possible, the captain should then position the vessel so that current should carry the tether away from the stern of the boat. The captain should not use bow thruster unless an emergency arises.
- The ROV pilot should obtain visual of TMS and have the winch operator raise the TMS to surface at a speed determined by the pilot.
- Depending on amount of tether deployed and surface conditions, the ROV pilot should stop ascension as the TMS is recovered to surface. The tether should be hauled onto deck by the deck officer and secured so as to not let the tether drift to the stern of the boat. The tether amount and angle should be monitored at all times, until the TMS is returned to water.
- Repairs to the TMS should begin immediately, while the ROV pilot, captain and survey personnel keep in constant communication and verify the location of the ROV.
- Once the TMS is repaired, the tether should be deployed by deck officer as the TMS is launched into the water. Once the TMS is in the water, the ROV pilot should obtain visual contact as soon as possible and follow the TMS down to safe latching depth. The ROV and TMS should then be recovered to surface as per normal procedures, and complete system checks should take place. The ROV contractor's office should be informed of the incident.
- If the TMS is not repairable on deck, the ROV should be brought along the starboard side of the vessel (recovery zone), where preparations should be made to lift the ROV onto the LARS with the starboard side crane. Once the TMS and ROV are on the LARS and secured, repairs should begin, and the ROV contractor's office should be notified.

### 9.3.7.5 LAUNCH AND RECOVERY SYSTEM FAILURE

- In event of LARS failure, the ROV pilot, if not already latched into the TMS, should do so immediately.
- The ROV supervisor should immediately inform the client representative and the captain of the vessel of the situation. The captain should slowly guide the vessel to a clear area if it is not tied up, or remain in place if the vessel is moored to a platform or barge.
- The ROV crew should begin to effect repairs to the LARS once the vessel is cleared in position to do so.
- The ROV contractor's office should immediately be informed of situation.
- Once repairs are effected, the ROV should be recovered immediately, and complete system checks should be performed.
- If repairs are not possible because of equipment limitations, the ROV supervisor should immediately report to the contractor's office to arrange express shipment of required replacement parts. If weather conditions permit, the ROV should be kept in water until such repairs can be made with continuous monitoring of system. (HPUs may be shut off.)
- Depending on which component of the LARS is not functional, various attempts to recover the ROV may be made using the system charge cart.
- The charge cart can be connected to the winch to haul the vehicle to surface. Once the TMS is sucked into the latching collar, hydraulics must be readily available to the swing frame latch circuit to close latches. Once the latches have the TMS mushroom in place, hydraulic supply can be switched between functions to land vehicle.
- If winch failure occurs, recovery of the vehicle may be attempted using crane sheaves to haul the umbilical to deck. The umbilical will be laid out across the back deck until the TMS mushroom is in the docking collar and latches are engaged. Extreme care should be taken during this procedure to prevent damage to the umbilical during this procedure, although there is considerable risk of this occurring. This procedure should occur only if all other conditions point to it (e.g., weather deterioration, vessel damage, etc.).
- f A-frame damage has occurred but the winch is still operational, the ROV and TMS will be recovered into the docking collar. If the A-frame must be landed at this time, crane rigging to the A-frame boom and opening of hydraulic flow to the boom rams will be completed. Once the crane is secured to the boom, the hydraulic lines will be opened to allow free flow, and the boom can then be manipulated into its landing position. **This procedure should occur only if all other conditions point to it (e.g., weather deterioration, vessel damage, etc.).**

### 9.3.7.6 VEHICLE ENTANGLEMENT

- In case of vehicle entanglement, the ROV supervisor should immediately inform the captain of the vessel, client representative and survey personnel. Survey personnel should record the current location of the ROV and plot boat drop for the vessel. The captain should also lock the location into the vessel's GPS in case of survey equipment failure.

- The ROV crew should watch entanglement of the ROV on the black box tape to discern any useful information to aid in recovery.
- If the vehicle cannot be recovered through ROV power, the pilot should haul the tether in with the TMS until it is tight. If tether management does not aid in freeing the ROV, then the ROV supervisor should call the ROV contractor's office to inform of current situation.
- Depending on the depth of the vehicle entanglement and operation considerations, inquiries should be made to the client for possible use of divers in freeing the vehicle.
- Last considerations include the use of a winch to pull the vehicle free. However, this option should be used only after consultation with the ROV contractor's office or if extremely dangerous working conditions existt.

### 9.3.7.7 ROV SYSTEM POWER FAILURE

- In the instance of complete system power failure, the ROV pilot should immediately shut off all system breakers and inform the client representative, the captain of the vessel, and survey crew of situation. Survey crew should track the vehicle, while the captain maneuvers the vessel to clear the area if the situation dictates.
- The ROV crew should trace down the source of the problem, beginning with generator status. If a problem is found, the crew should begin repairs immediately. The ROV contractor's office should be informed of the situation.
- If repairs cannot be effected immediately, the ROV supervisor should inform the client and captain of situation and give an ETA on repairs. The ROV supervisor should instruct the captain to post lookouts on all corners of bridge to spot the ROV in the event of tether separation the while system is down. If system components are needed but not in stock, the ROV supervisor should inform the ROV contractor's office for immediate shipment of parts. In the event of this situation, the TMS can be recovered to deck and the ROV can be recovered using the starboard crane on the vessel. All electrical safety practices must be followed.
- If the source of the problem is determined to be with the generator and repairs cannot be implemented in a timely manner (10 minutes), the ROV crew should change power cables to the backup generator or ship's emergency power. The supervisor should contact the ROV contractor's office to inform them of the situation and arrange for repair parts or shipment of new generator.

**Once again, these procedures should be used as guidelines only, and the supervisor will make all final decisions on site. Any circumstances considered out of the normal scope of operations will require consultation with the ROV contractor's office before extreme actions are taken. These procedures are to be addressed to the entire ROV crew and any relevant personnel onboard the vessel.**

## ADCI ROV TRAINING STANDARDS

The Association of Diving Contractors International, Inc. (ADCI), hereby recognizes and endorses this standard as one being acceptable for an entry-level remotely operated vehicle (ROV) pilot-technician.

The Association of Diving Contractors International, Inc. requires that an entry-level ROV pilot-technician at work must have received adequate training to safely undertake the work involved in the ROV operation. As part of this requirement, each ROV pilot-technician must possess a valid certificate of training. This may be:

- A certificate of training issued by an Association of Diving Contractors International, Inc accredited school; or
- Commercial ROV experience or combination of both commercial experience and training; or
- The equivalent of the training requirements as outlined in the ADCI standard.

**Competence Assessment**

Beginning in 2017, in its endeavor to foster better vocational training and education, the Association of Diving Contractors International, Inc (ADCI) encouraged the development of standards-based qualifications that focused on essential competence at the workplace and that was assessable, as well as understood, by employers, trainees and trainers.

ADCI subsequently developed the competence standard and related assessment requirements as set out in this document. Competence is determined through written tests, instructor evaluation, log book records, and the trainee's performance, attitude, and ability to conduct in-water ROV-related work tasks. In conjunction with an ROV training course, ROV pilot-technicians will be assessed by schools that have been accredited for this purpose. Theoretical competence forms the foundation for the application and is required when practical ability and skills depend on some element of knowledge and understanding. Where both theory and practice are indicated, pilot-technicians will be assessed both ways. Assessment records on each trainee will be maintained by individual training sites.

Although not spelled out as a specific competence, all pilot-technicians recommended for a certificate shall have achieved specified in-water times during training and assessment. Those times for training are set out in the published Entry Level ROV Pilot-Technician Training Minimum Standard and are further clarified in the standard where needed to avoid ambiguity.

**Competence Standard**

This new standard was derived from a comprehensive survey of industry requirements for both the onshore and offshore environments and reflects the diverse operational scenarios that employ ROV operators. This standard is comprehensive in nature and specifies minimum requirements for demonstrating competency.

The competence standard represents abilities that a ROV pilot-technician must demonstrate under testing before he or she can be issued an entry-level ROV pilot-technician certificate. This standard pertains whether the certificate is the result of training or experience, or both.

The competence standard is divided into sections that represent important aspects of a ROV pilot-technician's ability and can be identified as such by employers. These include, for example, complete ROV operational scenarios — the ability of the ROV pilot-technician to operate within a team to safely mobilize a system, perform basic calibration and troubleshooting, deploy the ROV system, dive the ROV underwater to the work site until the job is finished or the pilot time is up, return safely to the surface, and safely recover the ROV from the water and perform necessary post dive checks. Each section is further divided into main headings and subheadings. The latter provides the essential details on which the pilot-technician will be assessed.

The aim of the standard is to:

- Improve the quality of training, with both theoretical and practical applications, for entrants to ROV operations.
- Reduce the risk of accidents attributable to inadequate training.
- Establish consistent minimum training requirements to ensure continuity of training within the ADCI.
- Require that graduates be qualified and competent to dive an appropriate ROV and perform underwater work assignments before receiving a certificate.

This standard was developed to establish what is to be taught, the minimum length of training required for each section, the minimum qualifications for instructors, and the minimum facilities and equipment required to support that training. In developing this standard, subject matter that is similar, or closely related, is grouped together. Subject matter has been further subdivided into topics of manageable size for instructional purposes and detailed lesson planning. Such grouping is not intended as a training schedule.

After the effective date of the standard, the (ADCI) hereby recognizes and endorses this standard as the acceptable minimum training standard for the entry level ROV pilot-technician. All ROV pilots who can document an equivalent level of training through a combination of field experience and/or formal training prior to the original issue date (2018) are specifically exempt from its application.

ADCI provides accreditation to all of its member schools and ensures that a national system of ROV pilot-technician training is maintained. ROV pilot-technician training institutions wishing to become a member of ADCI are inspected and evaluated to ensure their training standards provide training for entry level ROV pilot-technicians at the level of this standard.

Questions regarding this standard and/or applications for membership in ADCI should be addressed to:

Association of Diving Contractors International
ADCI ROV Training Competency Assessment
5206 Cypress Creek Parkway Ste. 202
Houston, TX 77069
Phone: (281) 893-8388 or (281) 893-6438
Toll Free: (888) 718-4531
Fax: (281) 893-5118

Deviation from the standard may be made only to exceed or supplement the required training.

The order of sections presented by ADCI for training requirements is not restricted to the section sequence contained herein.

Differences

in facilities, equipment, local administrative requirements, state and federal laws and/or similar conditions may warrant modification of any established sequence. It is the responsibility of each school to provide for the efficient implementation and administration of this standard and to ensure that each topic presented herein is presented in a way that provides a maximum gain in knowledge and skill for each trainee. The minimum standard will be reviewed periodically to reflect changes in technology, techniques and other developments that are likely to occur in the commercial diving industry.

ENTRY LEVEL ROV PILOT-TECHNICIAN MINIMUM STANDARDS

Entry Level ROV Pilot-Technician certification is basic ROV training up to and including Class II ROVs as defined in 9.2.1.

To obtain an Entry Level ROV Pilot-Technician certificate of training, a student shall achieve a minimum of 110 hours of formal instruction.

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**1.1 General Requirements**

**1.1.1 Facilities**

Training facilities shall meet all federal, state and local requirements and laws. They should possess adequate space, equipment and safety regulations to offer safe and competent training. Aside from federal, state and local requirements, at a minimum, facilities will include classrooms with adequate lighting, tables, desks, seating, blackboards/whiteboards, audio-visual equipment, technical library, texts and training materials to support the student learning environment. Training facilities must be available to support practical, in- water training including shore based and vessel based operations, etc.

1.1.2 Staff

Each training facility should have adequate support staff to maintain high-quality teaching standards, facility, equipment, records and emergency procedures. Staff members should be selected for their competency in performing their assigned tasks.

**1.1.3 Instructors**

Schools should employ instructors with a minimum of two years of full-time working experience in related ROV operations, or areas of instruction taught, and should meet state educational requirements for vocational instructors. If required, instructors must meet state and/or city codes. All instructors should be trained in emergency policies and procedures.

**1.1.4 Equipment**

All ROV and support equipment will be properly maintained in accordance with manufacturer's specifications.

Practical training (hands-on) should be conducted with equipment that the trainee will use in the industry. Knowledge of newly developed equipment should be taught. Manufacturer's operational manuals must be available, as well as instruction manuals, equipment and tools for hands-on repair and maintenance. This must be in addition to equipment used for in-water operations.

All ROV pilot/technician training facilities will provide, at a minimum, at least two different types of operational ROV systems common to the industry as outlined in section 9.2.1 – vehicle classification. One of these operational ROV's must be an observation class vehicle (Class II) or higher. ROV systems that are not dive ready or fully operational can also be used for training but cannot be included in the minimum operational ROV requirement.

Other ROV and support equipment that must be provided on site as part of the training program includes, but is not limited to, the following:

a. Electronic/electrical diagnostic equipment including:
   Digital multimeters
   Meggers
   Power supplies
   Soldering equipment
   Spare copper tether
b. Acoustic locators and sonar devices including:
   USBL or LBL type system
   ROV integrated sonar system
c. Hydraulic/fluid power equipment including:
   Linear and rotary actuators
   Hydraulic hose construction systems
   Flow and pressure meters

d. Crane, davits, ROV handling systems and other lifting devices
e. Rigging equipment common to the ROV industry

**1.1.5 Training Aids**

Books and training aids should contain current information and be appropriate for individual courses and modules. Up-to-date audiovisual aids should be used with all applicable instruction. Students should be supplied with an ADCI ROV pilot log book, which must be maintained and updated on a regular basis.

**1.2 Physical Fitness**

The importance of physical fitness will be emphasized to students throughout the training program.

**1.3 Industry Input**

Close liaison with the safety, education and medical committees of the ADCI should be maintained to ensure that training meets industry requirements and needs. Contact with commercial ROV companies and equipment manufacturers should be maintained to ensure awareness of changes and improvements in equipment, procedures, safety requirements, etc.

**1.4 Employment**

Students shall be informed about employers' hiring policies regarding drugs and alcohol. Responsibilities of ROV pilots shall be included in the training. Rules and regulations for the United States Coast Guard, Association of Diving Contractors International (ADCI) Consensus Standards and OSHA shall be an integral part of the training.

**1.5 Safety**

Safety and compliance with federal, state and ADCI standards should be emphasized throughout the training program. Students will be instructed that the basic responsibility for both personal and operational safety lies with each individual.

**1.6 Documentation**

Documentation of all training successfully completed must be available to the student, including transcripts, diplomas, and certificates. Students will be issued and required to maintain an official ADCI logbook. Upon completion of training, an official ADCI certification card will be issued to each graduating student.

**1.7 Drug Policy**

Safety is of paramount importance. ADCI is committed to maintaining a safe, healthy work and training environment and is dedicated to providing a drug- and alcohol-free workplace.

A substance abuse policy should be strictly enforced. This will provide a means to minimize the use of intoxicants by personnel, staff, employees and trainees, and will enhance safe conduct of operations. The goals should be to attain the highest work and training standards possible and to promote a safe work environment, free of drugs and alcohol.

The goals and objectives of maintaining safety in a drug-free work environment are attainable through cooperation at every level and by explicitly and forcefully prohibiting the use, manufacture, distribution, dispensation and possession of illicit drugs, drug paraphernalia and alcohol at all training locations and diving operations.

**2.0 Entry Level ROV Pilot-Technician Program Content Requirements**

**2.1 Safety – 8 hours**

Safety and compliance with federal, state and ADCI standards should be emphasized throughout the training program. These hours are intended for ROV specific safety training, not including any other first aid training. Instruction in ROV specific safety should at a minimum include the following:

- Safety Management Systems
  - Personal safety PPE
  - Launch and recovery safety
  - Tether handling safety
  - Pre and Post dive check safety
  - Electrical safety
  - Emergency response plan

**2.2 Rigging – 8 hours**

Basic knots
Techniques for securing equipment on deck or operational platform
Line handling safety
Specific launch and recovery ringing

**2.3 Environmental Considerations – 4 hours**

Instruction in environmental considerations affecting operations and safety. A basic understanding of the following topics should be included in the training.

Influence of sea state and weather on ROV launch and recovery

Currents and the effects on tether drag and ROV direction of approach to work site

Influence of underwater visibility on video and lighting

Use of SONAR and tracking systems particularly in low visibility situations

Considerations of environment when live boating

Domain awareness (ROV and diver SIMOPS)

**2.4 Fluid Power, hydraulics, and mechanical systems – Required hours 8**

Basic understanding of the concepts and applications of fluid power technology and the necessary skills for troubleshooting hydraulic systems in the field. General concept of fluid power systems including an introduction to energy input, energy output, energy control, system, and auxiliary components. Design, repair, and maintenance of launch and recovery equipment which may include hoses, sensors and components associated with ROV hydraulics systems.

**2.6 Electricity and Electronics – required hours: 20**

Fundamentals of electricity and electronics by developing introductory analysis, construction and troubleshooting techniques for DC and AC circuits. Introduction of power supplies, transistors, amplifiers and digital logic families. Safe electrical practices, including industrial high voltage systems, read and follow schematics, and demonstrate proper wiring and soldering techniques. Electrical measurements shall be performed using test tools including multimeters. Additionally, systems, applications, electronics, and safety requirements specific to the marine and ROV environments shall be presented including the understanding of the design repair, and integration of cabling, tether, communication devices, sensors, and components. Use of test equipment and protocols in troubleshooting methods.

**2.8 Basic principles and classification of ROV systems – 2 hours**

Provide students with an understanding of basic principles of ROV systems including history, vehicle classification and function, service areas of industry and the major components of a ROV system

**2.9 ROV Components – Detailed – 20 hours**

Detailed instruction on ROV component systems including:

- Cameras and video systems
- Lighting systems
- Buoyancy and floatation
- Manipulator systems
- Positioning systems/tracking systems
- Propulsion systems
- Sonar systems
- Navigation systems
- Tether management and handling systems
- Vehicle control systems
- ROV topside control center
- Auxiliary systems
    - o CP
    - o Laser
    - o Inspection and Scientific sampling

**2.10 ROV Operations – Documented and signed off**

ROV operations training includes specific skills for Pilot, Navigator and Deck/Tether handling. Instruction in proper logs, documentation and record keeping should be emphasized.

1. Pilot in command – 10 hours

This is time under operational activities-i.e. ROV in the water.  ROV in-water operation time must include 75% of class II or above ROV as defined in 9.2.1.

Piloting/Flying

ROV station keeping

Transiting to and from work site using appropriate navigation systems

Pre and Post dive checks

Completing underwater job tasks

2. Navigator – 10 hours.

This is time under operational activities-i.e. ROV in the water.  ROV in-water operation time must include 75% of class II or above ROV as defined in 9.2.1.

Tracking system operation

SONAR operation

Record keeping and documentation

Manipulator operation

Video and media recording

3.Deck operations/tether handling – 20 hours

This is time under operational activities-i.e. ROV in the water.  ROV in-water operation time must include 75% of class II or above ROV as defined in 9.2.1.

Deck Safety

Launch and recovery

Pre and Post dive checks

Tether management

Environmental and situational awareness

ROV team communications

System mobilization and demobilization

# SECTION 10

# REFERENCE MATERIALS

Association of Diving Contractors International, Inc.

## 10.1 GLOSSARY OF TERMS

### ACFM (acfm)

Actual cubic feet per minute. Refers to the actual volume of gas supplied to a diver, bell, etc., at ambient pressure.

### ALST

Assistant Life Support Technician

### Ambient Pressure

The surrounding pressure at depth (actual or simulated, in a hyperbaric chamber) to which the diver, bell, etc., is subjected.

### Appropriate Breathing Mix

A breathing mixture that, having regard to the system and equipment used in the diving operations, the work undertaken in those operations, and the conditions in which and the depth at which they are to be carried out, is suitable in content and temperature and of adequate pressure.

### Ascent Times

The time interval between leaving the bottom when the dive is terminated and reaching the surface.

### ATA (ata)

Atmosphere absolute. Total pressure, including atmospheric, to which a diver, bell, etc., is subjected.

### ATM (atm)

Atmospheric (atm) unit equivalent to 14.7 psi or 760 (mm) of mercury.

### Bailout Bottle (EGS)

See **Diver-Worn or Carried Emergency Gas Supply.**

### Bar

A unit of pressure equal to 1 atmosphere (atm).

### Bell (Open Bell and Closed Bell)

An enclosed compartment, pressurized (closed bell) or un-pressurized (open bellm also known as Wet Bell), that allows the diver to be transported to and from the underwater work area and that may be used as a temporary refuge during diving operations.

### Bends

See **Decompression Sickness**.

### BIBS

Built-in breathing system. A breathing gas system built into all deck chambers and SDCs by which emergency breathing gas or a treatment gas can be supplied to the diver through an oral-nasal mask or hood.

### Bottom Time

The total elapsed time, measured in minutes, from the time that the diver leaves the surface in descent to the time that the diver begins ascent.

### Breathing System

Device or apparatus for delivering appropriate breathing mixture.

### Bursting Pressure

The pressure at which a pressure containment device would fail structurally.

## Cleaned for Oxygen Service

Cleaning of equipment or system to ensure elimination of all hydrocarbons and other potentially dangerous contaminants when system is to be used in oxygen service. See also **Oxygen Cleaning.**

## CNS

Central nervous system.

## Commercial Diver

An individual who has applied for and been awarded a certification card or other document recognized to reflect the formal training, field experience, on-the-job performance and capabilities of the individual.

## Compressor

A machine that raises air or other gasses to a pressure above 1 atmosphere.

## CPR

Cardio-pulmonary resuscitation. A combination of artificial respiration and artificial circulation.

## Cylinder

A pressure vessel for the storage of gasses.

## DDC

Deck decompression chamber, PVHO (pressure vessel for human occupancy). A deck chamber capable of controlled pressurization and depressurization.

## Decompression

Releasing from pressure or compression following a specific decompression table or procedure during ascent; ascending in the water or experiencing decreasing pressure in the chamber.

## Deck Decompression Chamber

A hyperbaric chamber which is an integral part of a deep diving system, located on a surface platform from which diving is conducted.

## Decompression Chamber

An enclosed space used to gradually decrease pressure to which a diver is exposed from ambient underwater pressure back to 1 atmosphere.

## Decompression Schedule

A time-depth profile with a specific bottom time and depth, whose application is calculated to safely reduce the pressure on a diver.

## Decompression Sickness (DCS or DCI)

A condition with a variety of symptoms that causes the formation of bubbles of gas in the blood or other tissues of the diver during or subsequent to ascent or other pressure reduction.

## Decompression Table

A set of decompression schedules developed and available from a recognized source of expertise (such as the U.S. Navy) or developed by a recognized diving physiologist on behalf of a company. Such table must have been thoroughly field tested and evaluated before being used in operational practice.

## Design Working Pressure of the System

The lowest pressure rating of any component of the system.

## Differential Pressure (Delta P)

Occurs when there is suction of water, or where water moves from an area of high pressure to one of low pressure. This flow may be the result of the movement of water under its own weight or an active process involving powered machinery (e.g., pumps or thrusters).

## Dive Location

The vessel or other structure from which dives are conducted and supported. More specifically, the point from which the actual dive is controlled.

## Dive Station

The site from which diving operations are directly controlled. This site shall also include any auxiliary or peripheral equipment necessary to the conduct of the diving operation.

## Dive Team

Tender/divers, divers and diver support personnel involved in a diving operation, including the diving supervisor.

## Diver's Indicator Light

A light attached to a diver for the purpose of indicating the position of the diver when he or she is on the surface of the water.

## Diver-Worn or Carried Emergency Gas Supply (Bailout)

The gas required to be worn/carried by the diver, while underwater.

## Diving Bell

**A tethered underwater underwater support system providing life-support services and used to transport divers.**

## Diving Harness

The combination of straps and fasteners used to attach equipment and umbilical to the diver that can be utilized as a lifting point to remove the diver from the water in the event of an emergency.

## Diving Operations

Any work operation requiring some type of diving or work underwater that involves planned human exposure to increased pressures to perform the job.

## Diving Operating Personnel

Any member of the dive team whose activities are regularly scheduled as necessary to conduct diving operations at or from the dive station.

## Diving Superintendent

A superintendent or designated diving supervisor having complete responsibility for the safety of the diving operation, including responsibility for the safety and health of all diving personnel.

## Diving Supervisor

An individual who, through training, experience, demonstrated competency, and certification, is appointed as the person responsible for executing the diving operation, ensuring the safety protocols are followed, and ensuring the overall safety of the diving operation.

## DMT

Diver medical technician.

## DPIC

Designated person in charge.

## DPO

Dynamically position operator. The operator of a dynamically positioned vessel.

## DP Vessel

Dynamically positioned vessel. A vessel that, through a computer controlled system, automatically maintains its position and heading by using its thrusters and propellers.

## Dual-lock Chamber

Multi-lock deck decompression chamber.

## Dry Suit

A diving suit designed to exclude water from the surface of the body.

## DSV

Dive spport vessel.

## Dynamic Positioning (DP)

A system that automatically controls a vessel's position and heading by means of thrusters. A typical DP system consists of a control system (including power management and position control), reference systems (such as position, heading, and environmental references) and power systems (including power generation, distribution and consumption. There are many different levels of redundancy for DP systems. DP 2 is the minimum required for diving operations.

## EES

Emergency evacuation system (i.e., HRC or SPHL).

## EGS

Emergency gas supply (bailout).

## Embolism

See **Gas Embolism.**

## Excursion Tables

Two tables for use with saturation excursion diving that limit upward and downward excursions and provide a zone in which the diver can move freely without regard to the number of excursions or their duration without incurring a decompression penalty.

## Exhaust Valve

A valve controlling the venting of gas from any higher pressure source such as a DDC, diver's helmet, suit, buoyancy system, volume tank, etc.

## FMEA

Failure modes and effect analysis. This is a methodology used to identify potential failure modes, determine their effects and identify actions to mitigate the failures.

## FSW (fsw)

A foot of seawater. A unit of pressure at sea level generally defined as representing the pressure exerted by a foot of seawater having a specific gravity of 1.027, and is equal to approximately 0.445 pounds per square inch.

## Gas Embolism

A condition caused by expanding gasses that have been taken into and retained in the lungs while breathing under pressure, being forced into the bloodstream or other tissues during ascent or decompression.

## GFCI (GFI)

A ground fault circuit interrupter attached to the topside AC power source having receptacles, any of which may be attached to underwater cables supplying power to tools or lighting.

### HAZID

Hazard identification

### Helium Unscrambler — Unscrambler — Speech Unscrambler

An electronic device designed to render intelligible the words spoken in a helium hyperbaric environment.

### High-pressure Nervous Syndrome (HPNS)

A group of symptoms, including a lack of coordination, tremors of the extremities, disorientation, nausea, dizziness, and brief lapses of consciousness occurring at depths of 500 feet or deeper.

### HPU

Hydraulic power unit.

### HIRA

Hazard identification and risk assessment

### HRC

Hyperbaric rescue chamber.

### HRV

Hyperbaric rescue vessel (SPHL)

### Hyperbaric Conditions

Pressure conditions in excess of surface pressure.

### Hyperbaric Reception Facility

A place to which evacuated saturation divers can be safely transported under pressure in either HRC or SPHL and transferred under pressure to other pressure vessels specifically intended to support the decompression of divers.

### Hypothermia

Profound loss of body heat.

### JHA (JHA, JHEA, SJA, TRA)

Job hazard analysis. Also called Job safety analysis, job hazard, evaluation analysis, and task risk assessment.

### LARS

Launch and recovery system.

### Liveboating

Liveboating is a diving technique where a single surface-supplied diver performs work underwater while his hose is being tended from the bow of a vessel and while the vessel is being manually operated by the vessel master and is underway using its main propulsion system.

### Life-support Control System (LSCS, LSP)

Fly-away support package with gas and facilities for EES system's life support and/or decompression of saturation divers in an emergency. A system designed for the support of deployed Emergency evacuation systems (HRC or SPHL). Also known as Life support package (LSP).

### LP

Low pressure (less than 500 PSI).

## LSS

Life support supervisor

## LST

Life-support technician/rack operator. Responsible for safe operation of hyperbaric system chambers; reports to diving supervisor.

## MOC - Management of Change

A formal process by which changes to normal operations procedures and/or policies are managed.

## Manifold

Panel for the distribution of diver breathing gas.

## Manifold Operator

Individual, such as an LST, diving supervisor or mixed-gas diver, who is designated to perform the duties of gas distribution on a surface-supplied mixed gas ($HeO_2$) diving operation, who is experienced and trained in the operation of the manifold, and whose primary responsibility is to operate the manifold.

## Master

Normally considered to be the person in charge of a marine asset.

## MAWP

Maximum allowable working pressure. See **Maximum Working Pressure**.

## Maximum Working Pressure

The maximum pressure to which a pressure containment device can be exposed under operating conditions.

## Med-lock

A lock located in the inner lock of a hyperbaric chamber, to facilitate the transfer of medical supplies, food or other articles between the chamber occupants and personnel outside.

## Mixed-Gas Diving ($HeO_2$)

A surface diving technique in which the diver is supplied with a bottom mix of helium and oxygen.

## MSW

Meters of sea water.

## NDT

Non-destructive testing

## Nitrox (Enriched Air) Diving

A diving technique in which the diver is supplied a bottom mix of nitrogen, plus oxygen in excess of 21%.

## No-decompression Diving

Diving that involves depths and times shallow and short enough so that the ascent can be made to the surface without water stops or subsequent chamber decompression.

## Non-return Valve (Check Valve)

A one-way check valve installed in a fluid or gas system to permit flow in one direction only. All diving helmets must have a non-return valve at the gas supply inlet to prevent depressurization of the helmet and the resultant squeeze, should the gas supply be lost.

### Oxygen Cleaning

Special cleaning process for equipment to be used in oxygen systems.

### Oxygen Compatibility

The ability of a substance to come in contact with oxygen without reaction.

### Oxygen Toxicity (CNS $O_2$)

A condition usually not encountered unless $PPO_2$ approaches or exceeds 1.6 ATA. However, could be encountered as low as 1.4 ATA.

### Oxygen Toxicity (Pulmonary $O_2$)

A condition from long exposures to increased $PPO_2$, causing a direct pulmonary irritation. Can occur during treatment tables 4, 7, 8, and also through back–to-back administration of treatment table 6.

### Partial Pressure

That portion of the total gas pressure exerted by a particular constituent of the breathing mixture.

### Person in Charge (Barge Captain - Installation Manager)

In relation to the craft/barge/structure, includes the captain or any other person made responsible by the owner for the vessel or facility, its operation, and the safety, health and welfare of those on board.

### Pneumofathometer (Kluge - Pneumo)

A depth-measuring device consisting of an open-end hose fixed to the diver, with the surface end connected to a gas supply and pressure gauge (usually marked in msw). Gauge measures pressure required to discharge water to depth of diver.

### PSIA

Pounds per square inch absolute (pounds per square inch gauge plus 1 atmosphere (14.7).

### PSI (psi)

Pounds per square inch. An expression of pressure; for example, 1 atmosphere equals 14.7 psi.

### PSIG

Pounds per square inch gauge (pounds per square inch absolute minus 1 atmosphere.

### PVHO

Pressure vessel for human occupancy.

### Relief Valve

A pressure-relieving device that prevents pressure from rising above a preset level.

### Risk Assessment

The process by which every perceived risk is identified, evaluated, and assessed, prior to commencement of operations. The findings and actions will be documented. A risk assessment is part of the risk management process.

### ROV

Remotely operated vehicle.

## Saturation Diving

Procedures in accordance with which a diver is continuously subjected to an ambient pressure greater than atmospheric pressure so that his or her body tissues and blood become saturated with the constituent elements of the breathing gas. Once the diver's body becomes saturated, he or she can remain within a specified zone for an unlimited time without incurring any additional decompression obligation.

## Scuba

Acronym for self-contained underwater breathing apparatus. Used to describe apparatus in which the inspired air is delivered by demand regulator and exhaled into the surrounding water (open-circuit); the air supply is carried on the diver's back. Primarily used for relatively shallow, recreational-related diving.

## SIMOPS

Simultaneous Operations

## SPHL

Self-propelled hyperbaric lifeboat.

## SWL

Safe working limit/load.

## Squeeze

A lack of equalization between parts of the body or between the body and the equipment. Extreme cases can cause severe injury or death.

## Standby Diver(s)

Another qualified diver at the dive location who is in a state of readiness to assist the diver in the water.

## Surface-Supplied Diving

A diving mode in which the diver receives his or her breathing gas from a supply on the surface.

## Tender

A term reserved for an apprentice diver or diver helper.

## Transfer Under Pressure Lock/Chamber (TUP)

A lock or chamber that allows the transfer to and from of diving personnel between the worksite and living chambers (also called deck decompression chambers) without disturbing off-duty divers in the complex. Transfer under pressure locks/chambers are essential where being subjected to ambient pressure may be life-threatening.

## Treatment Tables

A depth, time and breathing gas profile designed to treat a diver for gas embolism or decompression sickness.

## Umbilical

A hose bundle between the dive location and the diver or bell that supplies a lifeline, breathing gas, communications, power and heat as appropriate to the diving mode or conditions. Underwater television cameras and cabling can also be carried as a component part of the umbilical or can be taped or banded to it on a temporary basis.

## Valve

A device that starts, stops or regulates the flow of fluids or gas.

## Volume Tank

A pressure vessel connected to the outlet of a gas supply and used as a gas reservoir.

## Working Pressure

The pressure to which a pressure containment device is exposed under normal operating conditions.

## 10.2 PHYSICS AND FORMULAS

### PSIG to PSIA

**PSIA = PSIG + 14.7**
Round up to the next whole number.

### PSIA to PSIG

**PSIG = PSIA – 14.7**
Round up to the next whole number.

### Depth (fsw) to PSIG

**PSIG = Depth x .445**
Round up to next whole number.

### PSIG to Depth (fsw)

**Depth = PSIG divided by .445**
Round up to next whole number.

### PSIG to Atmosphere Absolute (ATA)

$$ATA = \frac{(PSIG + 14.7)}{14.7}$$

Carry two decimal places.

### Atmospheres Absolute (ATA) to PSIG

**(ATA – 1) x 14.7 = PSIG**

### Depth (fsw) to Atmospheres Absolute (ATA)

$$ATA = \frac{Depth + 33}{33}$$

Carry two decimal places.

### ATA to Depth (fsw)

**ATA – 1 x 33 = Depth (fsw)**
Round up to next whole number.

## Dalton's Law ("T" Formula)

**PP**

**ATA** | **% of Gas**

PP = Partial Pressure
% = Percent by Volume of the Identified Gas
ATA = Atmospheres Absolute

## Gay-Lussac's Law

$$P2 = \frac{P1 \times T2}{T1}$$

Volume is constant.
T1 = Initial Temperature (absolute)
T2 = Final Temperature (absolute)
P1 = Initial Pressure (absolute)
P2 = Final Pressure (absolute)

## Charles' Law

$$V2 = \frac{V1 \times T2}{T1}$$

Pressure is constant.
T1 = Initial Temperature (absolute)
T2 = Final Temperature (absolute)
V1 = Initial Volume (absolute)
V2 = Final Volume (absolute)

## Boyles' Law (Pressure/Volume Relationship)

$$\frac{DL + 33}{DA + 33} \times OV = NV$$

DL= Depth Left
DA = Depth Arrived
OV = Original Volume
NV = New Volume

## Henry's Law

**(The Law of Gas Absorption and Solubility) EXPLANATION:**

- "The amount of any given gas that will dissolve in a liquid at a given temperature is directly proportional to the partial pressure of that gas."
- Gas diffuses and dissolves in blood, because of the difference in partial pressure, between inhaled and exhaled air.
- The inert gas in the breathing media (nitrogen or helium) will be dissolved into the diver's body tissues as the diver is descending and during the time spent on bottom.
- Whatever gasses that have been dissolved in a diver's body tissues, at a given depth and pressure, will remain in the tissues, as long as the depth is maintained. As the diver starts to ascend, more and more of the dissolved gas will come out of his or her tissues. If his ascent is controlled, as through the use of the decompression table, the dissolved gas will be carried to the lungs and exhaled before it accumulates sufficiently to form significant bubbles in the blood or tissues.

## General Gas Law (Pressure/Volume/Temperature Relationship)

**(P1 x V1) ÷ T1 = (P2 x V2) ÷ T2**

## Degrees Fahrenheit to Rankine

**R° = F° + 460°**

## Degrees Celsius to Absolute

**C° + 273° = Degrees Kelvin**

## Degrees Fahrenheit to Celsius

**5 x (F°– 32°) ÷9 = Celsius (carry 1 decimal place)**

## Degrees Celsius to Fahrenheit

**(9 x C°) ÷ 5 = 32° = Fahrenheit (carry 1 decimal place)**

## Gas Volume Requirement Formula if Using an LP Compressor

**SCFM = ATA x ACFM x N**

## Gas Volume Requirement Formula if Using an HP Gas Bank

**SCF = ATA x ACFM x N x T**

SCFM = Standard Cubic Feet per Minute
SCF = Standard Cubic Feet
ATA = Atmospheres Absolute
ACFM = Actual Cubic Feet per Minute
N = Number of Divers
T = Time (always expressed in minutes)

## Minimum Manifold Pressure

**MMP = D x .445 + Over Bottom Pressure**
(OBP is established by company or a set standard used.)
Round up to next whole number.

## Average Gas Consumption Based Upon Moderate

| | |
|---|---|
| **Free-flow Type Hat (Desco, MK V)** | 4.5 ACFM |
| **Demand Type Hat (Superlite/Miller)** | 1.4 ACFM |
| **Built-in Breathing System (BIBS)** | 0.3 ACFM |

## Treatment Gas Mixtures ($O_2$/$HeO_2$/$N_2O_2$)

| Depth (fsw) | Gas Mixture | $PPO_2$ |
|---|---|---|
| 0 – 60 fsw | 100 % $O_2$ | 1.00 – 2.81 ATA |
| 61 – 165 fsw | 50/50% $HeO_2$ or $N_2O_2$ | 1.42 – 3.00 ATA |
| 166 – 225 fsw | 64/36% $HeO_2$ | 2.17 – 2.80 ATA |

## Example of Calculating Surface Interval

Reached surface (RS) @ 2305 hrs.
Left surface (LS) @ 0317 hrs. ( carry over 24-hr. clock )
0317 hrs. could be expressed, ONLY FOR THE PURPOSE OF CALCULATION, as 2717 hrs. 2717 minus (-) 2305 = 4:12
4 hrs. and 12 min.

## Calculating In-water Travel Time

1. Depth left (ft/m) minus (-) depth arrived (ft/m) = distance traveled (ft/m).
2. Distance traveled divided (÷) by ascent/descent rate = minutes (and/or percentage of a minute in decimal.
3. Whole number is minute(s). Decimal is percentage of minute. Take decimal and multiply (x) by 60 (number of seconds in a minute). Decimal will then convert to actual seconds.

**EXAMPLE:**

215 fsw – 87 fsw = 128 fsw Ascent rate: 30 fpm
128 fsw ÷ 30 fpm = 4.26 (4 minutes and .26 or 26% of a minute)
26 x 60 = 15.6 seconds (round up to next whole second) = 16 seconds
4 minutes and 16 seconds is your travel time from 215’ to 87’

## FORMULA DEFINITIONS

| | |
|---|---|
| **ACF** | Actual Cubic Feet |
| **ACFM** | Actual Cubic Feet per Minute |
| **ATA** | Atmospheres Absolute |
| **ATM** | Atmospheres |
| **CFM** | Cubic Feet per Minute |
| **D** | Diameter |
| **FFW** | Feet of Fresh Water |
| **FSW** | Feet of Sea Water |
| **FV** | Floodable Volume |
| **HP** | High Pressure |
| **LP** | Low Pressure |
| **MFW** | Meters of Fresh Water |
| **MSW** | Meters of Sea Water |
| **MWP** | Maximum Working Pressure |
| **PP** | Partial Pressure |
| **$PP0^2$** | Partial Pressure of Oxygen |
| **PPM** | Parts Per Million |
| **PSIG** | Pounds per Square Inch Gauge |
| **PSIA** | Pounds per Square Inch Absolute |
| **SCF** | Standard Cubic Feet |
| **SCFM** | Standard Cubic Feet per Minute |
| **V** | Volume |
| **W** | Weight |
| **WP** | Working Pressure |

## 10.3 ENGLISH METRIC EQUIVALENTS

| PRESSURE EQUIVALENTS | | | | |
|---|---|---|---|---|
| **Atmosphere** | **Bars** | **Pounds Per Square Inch (PSIG)** | **Columns of Mercury at 0˚C** | **Columns of Water at 15˚C** |
| 1 | 1.01325 | 14.696 | .76 meters / 29.92 inches | 10.33 MSW / 33.06 FSW |
| 0.986923 | 1 | 14.50 | .75 meters / 29.59 inches | 10.20 MSW / 32.63 FSW |
| 0.967841 | .98066 | 14.22 | .73 meters / 28.95 inches | 10.00 MSW / 32.00 FSW |
| .068046 | .068947 | 1 | .05 meters /2.03 inches | .70 MSW / 2.25 FSW |
| 1.31579 | 1.33322 | 19.33 | 1 meters / 39.37 inches | 13.60 MSW / 43.50 FSW |
| .0334211 | .0338639 | .4911 | .0254 meters / 1 inch | .345 MSW / 1.10 FSW |
| .09674 | .09798 | 1.421 | .0735 meters / 2.89 inches | 1 MSW / 3.19 FSW |
| .002456 | .002489 | .0360 | .0018 meters / .0735 inches | .025 MSW / .0812 FSW |
| .029487 | .029877 | .4333 | .0224 meters / .8822 inches | .304 MSW / .975 FSW |
| .030242 | .03064271 | .4444 | .0229 meters / .9048 inches | .3126 MSW / 1 FSW |

| MASS EQUIVALENTS | | | | | | |
|---|---|---|---|---|---|---|
| Kilograms | Grams | Ounces | Pounds | Tons (short) | Tons (long) | Tons (metric) |
| 1 | 1000 | 35.274 | 2.20462 | $1.1023x10^{-3}$ | $9.942x10^{-4}$ | 0.001 |
| 0.001 | 1 | 0.035274 | $2.2046x10^{-3}$ | $1.1023x10^{-6}$ | $9.842x10^{-7}$ | 0.000001 |
| $6.479x10^{-5}$ | 0.6047989 | $2.2857x10^{-3}$ | $1.4286x10^{-4}$ | $7.1429x10^{-8}$ | $6.3776x10^{-8}$ | $6.4799x10^{-8}$ |
| 0.0283495 | 28.3495 | 1 | 0.0625 | $3.125x10^{-5}$ | $2.790x10^{-5}$ | $2.835x10^{-5}$ |
| 0.453592 | 453.592 | 16 | 1 | 0.0005 | $4.4543x10^{-4}$ | $4.5359x10^{-4}$ |
| 907.185 | 907185 | 32000 | 2000 | 1 | 0.892857 | 0.907185 |
| 1016.05 | $1.016x10^{6}$ | 35840 | 2240 | 1.12 | 1 | 1.01605 |
| 1000 | $10^{6}$ | 35274 | 2204.62 | 1.10231 | 0.984206 | 1 |

| LENGTH EQUIVALENTS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Centimeters | Meters | Kilometers | Inches | Feet | Yards | Fathom | Miles | Nautical Mi. |
| 1 | 0.01 | 0.00001 | .3937 | .0328 | .0109 | .005468 | $6.21x10^{-5}$ | $5.36x10^{-6}$ |
| 2.54 | 0.025 | $2540x10^{-5}$ | 1 | .0833 | .0277 | .01388 | $1.57x10^{-5}$ | $1.37x10^{-5}$ |
| 30.48 | 0.3048 | $3048x10^{-4}$ | 12 | 1 | .3333 | .16666 | $1.89x10^{-4}$ | $1.64x10^{-4}$ |
| 91.44 | 0.9144 | $9.14x10^{-4}$ | 36 | 3 | 1 | .5 | $5.68x10^{-4}$ | $4.93x10^{-4}$ |
| 100 | 1 | 0.001 | 39.37 | 3.28 | 1.093 | .5468 | $6.21x10^{-4}$ | 5.39x10-$^{4}$ |
| 182.88 | 1.828 | .000182 | 72 | 6 | 2 | 1 | .00113 | $9.86x10^{-4}$ |
| 100,000 | 1,000 | 1 | 39,370 | 3,280.83 | 1,093.61 | 546.8 | .6213 | .5395 |
| 160,935 | 1609.35 | 1.609 | 63,360 | 5,280 | 1,760 | 880 | 1 | .8683 |
| 185,325 | 1853.25 | 1.853 | 72,962.4 | 6,080.4 | 2,026.73 | 1,013.36 | 1.1515 | 1 |

| VOLUME AND CAPACITY EQUIVALENTS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cubic Centimeters | Milliliter | Liter | Cubic Inches | Cubic Feet | Cubic Yards | Pint | Quart | Gallon |
| 1 | .99997 | $9.99x10^{-4}$ | .061023 | $3.53x10^{-5}$ | $1.30x10^{-6}$ | $2.113x10^{-3}$ | $1.056x10^{-3}$ | $2.641x10^{-4}$ |
| 16.387 | 16.387 | .016386 | 1 | 5.78x10-4 | 2.14x10-3 | .034632 | .017316 | $4.329x10^{-3}$ |
| 28,317 | 28,316.2 | 28317 | 1728 | 1 | .037037 | 59.84448 | 29.9221 | 7.48052 |
| 764,559 | 764,559 | 764.53 | 46,656 | 27 | 1 | 1615.79 | 807.896 | 201.974 |
| 1.00 | 1 | .001 | .061025 | $3.53x10^{-5}$ | $1.308x10^{-6}$ | $2.11x10^{-3}$ | $1.056x10^{-3}$ | $2.641x10^{-4}$ |
| 1000.03 | 1,000 | 1 | 61.0251 | .0353154 | $1.308x10^{-3}$ | 2.11342 | 1.05671 | .264178 |
| 473.179 | 473.166 | .47316 | 28.875 | .0167101 | $6.188x10^{-4}$ | 1 | 0.5 | .125 |
| 946.359 | 946.359 | .9463 | 57.75 | .0334201 | $1.237x10^{-3}$ | 2 | 1 | .25 |
| 3,785 | 3,785 | 3.785 | 231 | .133681 | $49511x10^{-3}$ | 8 | 4 | 1 |

## 10.4 BAILOUT CALCULATIONS (Cu. Ft.)

| BAILOUT CALCULATIONS FOR 30 Cu. Ft. CYLINDERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth fsw | Depth psi | ATA | Rate cu.ft / min | Cylinder psi | Cylinder volume cu.ft | Delivery Pressure depth in psi + 150 psi reg press. | Usable Gas pressure | Usable Gas cu.ft / bottle | Duration Minutes at Depth |
| 1000 | 445.00 | 31.30 | 1.5 | 3000 | 30 | 595.00 | 2405.00 | 24.05 | 0.51 |
| 975 | 433.88 | 30.55 | 1.5 | 3000 | 30 | 583.88 | 2416.13 | 24.16 | 0.53 |
| 950 | 422.75 | 29.79 | 1.5 | 3000 | 30 | 572.75 | 2427.25 | 24.27 | 0.54 |
| 925 | 411.63 | 29.03 | 1.5 | 3000 | 30 | 561.63 | 2438.38 | 24.38 | 0.56 |
| 900 | 400.50 | 28.27 | 1.5 | 3000 | 30 | 550.50 | 2449.50 | 24.50 | 0.58 |
| 875 | 389.38 | 27.52 | 1.5 | 3000 | 30 | 539.38 | 2460.63 | 24.61 | 0.60 |
| 850 | 378.25 | 26.76 | 1.5 | 3000 | 30 | 528.25 | 2471.75 | 24.72 | 0.62 |
| 825 | 367.13 | 26.00 | 1.5 | 3000 | 30 | 517.13 | 2482.88 | 24.83 | 0.64 |
| 800 | 356.00 | 25.24 | 1.5 | 3000 | 30 | 506.00 | 2494.00 | 24.94 | 0.66 |
| 775 | 344.88 | 24.48 | 1.5 | 3000 | 30 | 494.88 | 2505.13 | 25.05 | 0.68 |
| 750 | 333.75 | 23.73 | 1.5 | 3000 | 30 | 483.75 | 2516.25 | 25.16 | 0.71 |
| 725 | 322.63 | 22.97 | 1.5 | 3000 | 30 | 472.63 | 2527.38 | 25.27 | 0.73 |
| 700 | 311.50 | 22.21 | 1.5 | 3000 | 30 | 461.50 | 2538.50 | 25.39 | 0.76 |
| 675 | 300.38 | 21.45 | 1.5 | 3000 | 30 | 450.38 | 2549.63 | 25.50 | 0.79 |
| 650 | 289.25 | 20.70 | 1.5 | 3000 | 30 | 439.25 | 2560.75 | 25.61 | 0.82 |
| 625 | 278.13 | 19.94 | 1.5 | 3000 | 30 | 428.13 | 2571.88 | 25.72 | 0.86 |
| 600 | 267.00 | 19.18 | 1.5 | 3000 | 30 | 417.00 | 2583.00 | 25.83 | 0.90 |
| 575 | 255.88 | 18.42 | 1.5 | 3000 | 30 | 405.88 | 2594.13 | 25.94 | 0.94 |
| 550 | 244.75 | 17.67 | 1.5 | 3000 | 30 | 394.75 | 2605.25 | 26.05 | 0.98 |
| 525 | 233.63 | 16.91 | 1.5 | 3000 | 30 | 383.63 | 2616.38 | 26.16 | 1.03 |
| 500 | 222.50 | 16.15 | 1.5 | 3000 | 30 | 372.50 | 2627.50 | 26.28 | 1.08 |
| 475 | 211.38 | 15.39 | 1.5 | 3000 | 30 | 361.38 | 2638.63 | 26.39 | 1.14 |
| 450 | 200.25 | 14.64 | 1.5 | 3000 | 30 | 350.25 | 2649.75 | 26.50 | 1.21 |
| 425 | 189.13 | 13.88 | 1.5 | 3000 | 30 | 339.13 | 2660.88 | 26.61 | 1.28 |
| 400 | 178.00 | 13.12 | 1.5 | 3000 | 30 | 328.00 | 2672.00 | 26.72 | 1.36 |
| 375 | 166.88 | 12.36 | 1.5 | 3000 | 30 | 316.88 | 2683.13 | 26.83 | 1.45 |
| 350 | 155.75 | 11.61 | 1.5 | 3000 | 30 | 305.75 | 2694.25 | 26.94 | 1.55 |
| 325 | 144.63 | 10.85 | 1.5 | 3000 | 30 | 294.63 | 2705.38 | 27.05 | 1.66 |
| 300 | 133.50 | 10.09 | 1.5 | 3000 | 30 | 283.50 | 2716.50 | 27.17 | 1.79 |
| 275 | 122.38 | 9.33 | 1.5 | 3000 | 30 | 272.38 | 2727.63 | 27.28 | 1.95 |
| 250 | 111.25 | 8.58 | 1.5 | 3000 | 30 | 261.25 | 2738.75 | 27.39 | 2.13 |
| 225 | 100.13 | 7.82 | 1.5 | 3000 | 30 | 250.13 | 2749.88 | 27.50 | 2.34 |
| 200 | 89.00 | 7.06 | 1.5 | 3000 | 30 | 239.00 | 2761.00 | 27.61 | 2.61 |
| 175 | 77.88 | 6.30 | 1.5 | 3000 | 30 | 227.88 | 2772.13 | 27.72 | 2.93 |
| 150 | 66.75 | 5.55 | 1.5 | 3000 | 30 | 216.75 | 2783.25 | 27.83 | 3.35 |
| 125 | 55.63 | 4.79 | 1.5 | 3000 | 30 | 205.63 | 2794.38 | 27.94 | 3.89 |
| 100 | 44.50 | 4.03 | 1.5 | 3000 | 30 | 194.50 | 2805.50 | 28.06 | 4.64 |
| 75 | 33.38 | 3.27 | 1.5 | 3000 | 30 | 183.38 | 2816.63 | 28.17 | 5.74 |
| 50 | 22.25 | 2.52 | 1.5 | 3000 | 30 | 172.25 | 2827.75 | 28.28 | 7.50 |
| 25 | 11.13 | 1.76 | 1.5 | 3000 | 30 | 161.13 | 2838.88 | 28.39 | 10.77 |

| BAILOUT CALCULATIONS FOR 40 Cu. Ft. CYLINDERS at 3000 psi | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth fsw | Depth psi | ATA | Rate cu.ft / min | Cylinder psi | Cylinder volume cu.ft | Delivery Pressure depth in psi + 150 psi reg press. | Usable Gas pressure | Usable Gas cu.ft / bottle | Duration Minutes at Depth |
| 1000 | 445.00 | 31.30 | 1.5 | 3000 | 40 | 595.00 | 2405.00 | 32.07 | 0.68 |
| 975 | 433.88 | 30.55 | 1.5 | 3000 | 40 | 583.88 | 2416.13 | 32.22 | 0.70 |
| 950 | 422.75 | 29.79 | 1.5 | 3000 | 40 | 572.75 | 2427.25 | 32.36 | 0.72 |
| 925 | 411.63 | 29.03 | 1.5 | 3000 | 40 | 561.63 | 2438.38 | 32.51 | 0.75 |
| 900 | 400.50 | 28.27 | 1.5 | 3000 | 40 | 550.50 | 2449.50 | 32.66 | 0.77 |
| 875 | 389.38 | 27.52 | 1.5 | 3000 | 40 | 539.38 | 2460.63 | 32.81 | 0.79 |
| 850 | 378.25 | 26.76 | 1.5 | 3000 | 40 | 528.25 | 2471.75 | 32.96 | 0.82 |
| 825 | 367.13 | 26.00 | 1.5 | 3000 | 40 | 517.13 | 2482.88 | 33.11 | 0.85 |
| 800 | 356.00 | 25.24 | 1.5 | 3000 | 40 | 506.00 | 2494.00 | 33.25 | 0.88 |
| 775 | 344.88 | 24.48 | 1.5 | 3000 | 40 | 494.88 | 2505.13 | 33.40 | 0.91 |
| 750 | 333.75 | 23.73 | 1.5 | 3000 | 40 | 483.75 | 2516.25 | 33.55 | 0.94 |
| 725 | 322.63 | 22.97 | 1.5 | 3000 | 40 | 472.63 | 2527.38 | 33.70 | 0.98 |
| 700 | 311.50 | 22.21 | 1.5 | 3000 | 40 | 461.50 | 2538.50 | 33.85 | 1.02 |
| 675 | 300.38 | 21.45 | 1.5 | 3000 | 40 | 450.38 | 2549.63 | 34.00 | 1.06 |
| 650 | 289.25 | 20.70 | 1.5 | 3000 | 40 | 439.25 | 2560.75 | 34.14 | 1.10 |
| 625 | 278.13 | 19.94 | 1.5 | 3000 | 40 | 428.13 | 2571.88 | 34.29 | 1.15 |
| 600 | 267.00 | 19.18 | 1.5 | 3000 | 40 | 417.00 | 2583.00 | 34.44 | 1.20 |
| 575 | 255.88 | 18.42 | 1.5 | 3000 | 40 | 405.88 | 2594.13 | 34.59 | 1.25 |
| 550 | 244.75 | 17.67 | 1.5 | 3000 | 40 | 394.75 | 2605.25 | 34.74 | 1.31 |
| 525 | 233.63 | 16.91 | 1.5 | 3000 | 40 | 383.63 | 2616.38 | 34.89 | 1.38 |
| 500 | 222.50 | 16.15 | 1.5 | 3000 | 40 | 372.50 | 2627.50 | 35.03 | 1.45 |
| 475 | 211.38 | 15.39 | 1.5 | 3000 | 40 | 361.38 | 2638.63 | 35.18 | 1.52 |
| 450 | 200.25 | 14.64 | 1.5 | 3000 | 40 | 350.25 | 2649.75 | 35.33 | 1.61 |
| 425 | 189.13 | 13.88 | 1.5 | 3000 | 40 | 339.13 | 2660.88 | 35.48 | 1.70 |
| 400 | 178.00 | 13.12 | 1.5 | 3000 | 40 | 328.00 | 2672.00 | 35.63 | 1.81 |
| 375 | 166.88 | 12.36 | 1.5 | 3000 | 40 | 316.88 | 2683.13 | 35.78 | 1.93 |
| 350 | 155.75 | 11.61 | 1.5 | 3000 | 40 | 305.75 | 2694.25 | 35.92 | 2.06 |
| 325 | 144.63 | 10.85 | 1.5 | 3000 | 40 | 294.63 | 2705.38 | 36.07 | 2.22 |
| 300 | 133.50 | 10.09 | 1.5 | 3000 | 40 | 283.50 | 2716.50 | 36.22 | 2.39 |
| 275 | 122.38 | 9.33 | 1.5 | 3000 | 40 | 272.38 | 2727.63 | 36.37 | 2.60 |
| 250 | 111.25 | 8.58 | 1.5 | 3000 | 40 | 261.25 | 2738.75 | 36.52 | 2.84 |
| 225 | 100.13 | 7.82 | 1.5 | 3000 | 40 | 250.13 | 2749.88 | 36.67 | 3.13 |
| 200 | 89.00 | 7.06 | 1.5 | 3000 | 40 | 239.00 | 2761.00 | 36.81 | 3.48 |
| 175 | 77.88 | 6.30 | 1.5 | 3000 | 40 | 227.88 | 2772.13 | 36.96 | 3.91 |
| 150 | 66.75 | 5.55 | 1.5 | 3000 | 40 | 216.75 | 2783.25 | 37.11 | 4.46 |
| 125 | 55.63 | 4.79 | 1.5 | 3000 | 40 | 205.63 | 2794.38 | 37.26 | 5.19 |
| 100 | 44.50 | 4.03 | 1.5 | 3000 | 40 | 194.50 | 2805.50 | 37.41 | 6.19 |
| 75 | 33.38 | 3.27 | 1.5 | 3000 | 40 | 183.38 | 2816.63 | 37.56 | 7.65 |
| 50 | 22.25 | 2.52 | 1.5 | 3000 | 40 | 172.25 | 2827.75 | 37.70 | 9.99 |
| 25 | 11.13 | 1.76 | 1.5 | 3000 | 40 | 161.13 | 2838.88 | 37.85 | 14.36 |

| BAILOUT CALCULATIONS FOR 50 Cu. Ft. CYLINDERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth fsw | Depth psi | ATA | Rate cu.ft / min | Cylinder psi | Cylinder volume cu.ft | Delivery Pressure depth in psi + 150 psi reg press. | Usable Gas pressure | Usable Gas cu.ft / bottle | Duration Minutes at Depth |
| 1000 | 445.00 | 31.30 | 1.5 | 3000 | 50 | 595.00 | 2405.00 | 40.08 | 0.85 |
| 975 | 433.88 | 30.55 | 1.5 | 3000 | 50 | 583.88 | 2416.13 | 40.27 | 0.88 |
| 950 | 422.75 | 29.79 | 1.5 | 3000 | 50 | 572.75 | 2427.25 | 40.45 | 0.91 |
| 925 | 411.63 | 29.03 | 1.5 | 3000 | 50 | 561.63 | 2438.38 | 40.64 | 0.93 |
| 900 | 400.50 | 28.27 | 1.5 | 3000 | 50 | 550.50 | 2449.50 | 40.83 | 0.96 |
| 875 | 389.38 | 27.52 | 1.5 | 3000 | 50 | 539.38 | 2460.63 | 41.01 | 0.99 |
| 850 | 378.25 | 26.76 | 1.5 | 3000 | 50 | 528.25 | 2471.75 | 41.20 | 1.03 |
| 825 | 367.13 | 26.00 | 1.5 | 3000 | 50 | 517.13 | 2482.88 | 41.38 | 1.06 |
| 800 | 356.00 | 25.24 | 1.5 | 3000 | 50 | 506.00 | 2494.00 | 41.57 | 1.10 |
| 775 | 344.88 | 24.48 | 1.5 | 3000 | 50 | 494.88 | 2505.13 | 41.75 | 1.14 |
| 750 | 333.75 | 23.73 | 1.5 | 3000 | 50 | 483.75 | 2516.25 | 41.94 | 1.18 |
| 725 | 322.63 | 22.97 | 1.5 | 3000 | 50 | 472.63 | 2527.38 | 42.12 | 1.22 |
| 700 | 311.50 | 22.21 | 1.5 | 3000 | 50 | 461.50 | 2538.50 | 42.31 | 1.27 |
| 675 | 300.38 | 21.45 | 1.5 | 3000 | 50 | 450.38 | 2549.63 | 42.49 | 1.32 |
| 650 | 289.25 | 20.70 | 1.5 | 3000 | 50 | 439.25 | 2560.75 | 42.68 | 1.37 |
| 625 | 278.13 | 19.94 | 1.5 | 3000 | 50 | 428.13 | 2571.88 | 42.86 | 1.43 |
| 600 | 267.00 | 19.18 | 1.5 | 3000 | 50 | 417.00 | 2583.00 | 43.05 | 1.50 |
| 575 | 255.88 | 18.42 | 1.5 | 3000 | 50 | 405.88 | 2594.13 | 43.24 | 1.56 |
| 550 | 244.75 | 17.67 | 1.5 | 3000 | 50 | 394.75 | 2605.25 | 43.42 | 1.64 |
| 525 | 233.63 | 16.91 | 1.5 | 3000 | 50 | 383.63 | 2616.38 | 43.61 | 1.72 |
| 500 | 222.50 | 16.15 | 1.5 | 3000 | 50 | 372.50 | 2627.50 | 43.79 | 1.81 |
| 475 | 211.38 | 15.39 | 1.5 | 3000 | 50 | 361.38 | 2638.63 | 43.98 | 1.90 |
| 450 | 200.25 | 14.64 | 1.5 | 3000 | 50 | 350.25 | 2649.75 | 44.16 | 2.01 |
| 425 | 189.13 | 13.88 | 1.5 | 3000 | 50 | 339.13 | 2660.88 | 44.35 | 2.13 |
| 400 | 178.00 | 13.12 | 1.5 | 3000 | 50 | 328.00 | 2672.00 | 44.53 | 2.26 |
| 375 | 166.88 | 12.36 | 1.5 | 3000 | 50 | 316.88 | 2683.13 | 44.72 | 2.41 |
| 350 | 155.75 | 11.61 | 1.5 | 3000 | 50 | 305.75 | 2694.25 | 44.90 | 2.58 |
| 325 | 144.63 | 10.85 | 1.5 | 3000 | 50 | 294.63 | 2705.38 | 45.09 | 2.77 |
| 300 | 133.50 | 10.09 | 1.5 | 3000 | 50 | 283.50 | 2716.50 | 45.28 | 2.99 |
| 275 | 122.38 | 9.33 | 1.5 | 3000 | 50 | 272.38 | 2727.63 | 45.46 | 3.25 |
| 250 | 111.25 | 8.58 | 1.5 | 3000 | 50 | 261.25 | 2738.75 | 45.65 | 3.55 |
| 225 | 100.13 | 7.82 | 1.5 | 3000 | 50 | 250.13 | 2749.88 | 45.83 | 3.91 |
| 200 | 89.00 | 7.06 | 1.5 | 3000 | 50 | 239.00 | 2761.00 | 46.02 | 4.34 |
| 175 | 77.88 | 6.30 | 1.5 | 3000 | 50 | 227.88 | 2772.13 | 46.20 | 4.89 |
| 150 | 66.75 | 5.55 | 1.5 | 3000 | 50 | 216.75 | 2783.25 | 46.39 | 5.58 |
| 125 | 55.63 | 4.79 | 1.5 | 3000 | 50 | 205.63 | 2794.38 | 46.57 | 6.48 |
| 100 | 44.50 | 4.03 | 1.5 | 3000 | 50 | 194.50 | 2805.50 | 46.76 | 7.73 |
| 75 | 33.38 | 3.27 | 1.5 | 3000 | 50 | 183.38 | 2816.63 | 46.94 | 9.56 |
| 50 | 22.25 | 2.52 | 1.5 | 3000 | 50 | 172.25 | 2827.75 | 47.13 | 12.49 |
| 25 | 11.13 | 1.76 | 1.5 | 3000 | 50 | 161.13 | 2838.88 | 47.31 | 17.95 |

| BAILOUT CALCULATIONS FOR 80 Cu. Ft. CYLINDERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth fsw | Depth psi | ATA | Rate cu.ft / min | Cylinder psi | Cylinder volume cu.ft | Delivery Pressure depth in psi + 150 psi reg press. | Usable Gas pressure | Usable Gas cu.ft / bottle | Duration Minutes at Depth |
| 1000 | 445.00 | 31.30 | 1.5 | 3000 | 80 | 595.00 | 2405.00 | 64.13 | 1.37 |
| 975 | 433.88 | 30.55 | 1.5 | 3000 | 80 | 583.88 | 2416.13 | 64.43 | 1.41 |
| 950 | 422.75 | 29.79 | 1.5 | 3000 | 80 | 572.75 | 2427.25 | 64.73 | 1.45 |
| 925 | 411.63 | 29.03 | 1.5 | 3000 | 80 | 561.63 | 2438.38 | 65.02 | 1.49 |
| 900 | 400.50 | 28.27 | 1.5 | 3000 | 80 | 550.50 | 2449.50 | 65.32 | 1.54 |
| 875 | 389.38 | 27.52 | 1.5 | 3000 | 80 | 539.38 | 2460.63 | 65.62 | 1.59 |
| 850 | 378.25 | 26.76 | 1.5 | 3000 | 80 | 528.25 | 2471.75 | 65.91 | 1.64 |
| 825 | 367.13 | 26.00 | 1.5 | 3000 | 80 | 517.13 | 2482.88 | 66.21 | 1.70 |
| 800 | 356.00 | 25.24 | 1.5 | 3000 | 80 | 506.00 | 2494.00 | 66.51 | 1.76 |
| 775 | 344.88 | 24.48 | 1.5 | 3000 | 80 | 494.88 | 2505.13 | 66.80 | 1.82 |
| 750 | 333.75 | 23.73 | 1.5 | 3000 | 80 | 483.75 | 2516.25 | 67.10 | 1.89 |
| 725 | 322.63 | 22.97 | 1.5 | 3000 | 80 | 472.63 | 2527.38 | 67.40 | 1.96 |
| 700 | 311.50 | 22.21 | 1.5 | 3000 | 80 | 461.50 | 2538.50 | 67.69 | 2.03 |
| 675 | 300.38 | 21.45 | 1.5 | 3000 | 80 | 450.38 | 2549.63 | 67.99 | 2.11 |
| 650 | 289.25 | 20.70 | 1.5 | 3000 | 80 | 439.25 | 2560.75 | 68.29 | 2.20 |
| 625 | 278.13 | 19.94 | 1.5 | 3000 | 80 | 428.13 | 2571.88 | 68.58 | 2.29 |
| 600 | 267.00 | 19.18 | 1.5 | 3000 | 80 | 417.00 | 2583.00 | 68.88 | 2.39 |
| 575 | 255.88 | 18.42 | 1.5 | 3000 | 80 | 405.88 | 2594.13 | 69.18 | 2.50 |
| 550 | 244.75 | 17.67 | 1.5 | 3000 | 80 | 394.75 | 2605.25 | 69.47 | 2.62 |
| 525 | 233.63 | 16.91 | 1.5 | 3000 | 80 | 383.63 | 2616.38 | 69.77 | 2.75 |
| 500 | 222.50 | 16.15 | 1.5 | 3000 | 80 | 372.50 | 2627.50 | 70.07 | 2.89 |
| 475 | 211.38 | 15.39 | 1.5 | 3000 | 80 | 361.38 | 2638.63 | 70.36 | 3.05 |
| 450 | 200.25 | 14.64 | 1.5 | 3000 | 80 | 350.25 | 2649.75 | 70.66 | 3.22 |
| 425 | 189.13 | 13.88 | 1.5 | 3000 | 80 | 339.13 | 2660.88 | 70.96 | 3.41 |
| 400 | 178.00 | 13.12 | 1.5 | 3000 | 80 | 328.00 | 2672.00 | 71.25 | 3.62 |
| 375 | 166.88 | 12.36 | 1.5 | 3000 | 80 | 316.88 | 2683.13 | 71.55 | 3.86 |
| 350 | 155.75 | 11.61 | 1.5 | 3000 | 80 | 305.75 | 2694.25 | 71.85 | 4.13 |
| 325 | 144.63 | 10.85 | 1.5 | 3000 | 80 | 294.63 | 2705.38 | 72.14 | 4.43 |
| 300 | 133.50 | 10.09 | 1.5 | 3000 | 80 | 283.50 | 2716.50 | 72.44 | 4.79 |
| 275 | 122.38 | 9.33 | 1.5 | 3000 | 80 | 272.38 | 2727.63 | 72.74 | 5.20 |
| 250 | 111.25 | 8.58 | 1.5 | 3000 | 80 | 261.25 | 2738.75 | 73.03 | 5.68 |
| 225 | 100.13 | 7.82 | 1.5 | 3000 | 80 | 250.13 | 2749.88 | 73.33 | 6.25 |
| 200 | 89.00 | 7.06 | 1.5 | 3000 | 80 | 239.00 | 2761.00 | 73.63 | 6.95 |
| 175 | 77.88 | 6.30 | 1.5 | 3000 | 80 | 227.88 | 2772.13 | 73.92 | 7.82 |
| 150 | 66.75 | 5.55 | 1.5 | 3000 | 80 | 216.75 | 2783.25 | 74.22 | 8.92 |
| 125 | 55.63 | 4.79 | 1.5 | 3000 | 80 | 205.63 | 2794.38 | 74.52 | 10.38 |
| 100 | 44.50 | 4.03 | 1.5 | 3000 | 80 | 194.50 | 2805.50 | 74.81 | 12.38 |
| 75 | 33.38 | 3.27 | 1.5 | 3000 | 80 | 183.38 | 2816.63 | 75.11 | 15.30 |
| 50 | 22.25 | 2.52 | 1.5 | 3000 | 80 | 172.25 | 2827.75 | 75.41 | 19.99 |
| 25 | 11.13 | 1.76 | 1.5 | 3000 | 80 | 161.13 | 2838.88 | 75.70 | 28.72 |

| BAILOUT CALCULATIONS FOR 120 Cu. Ft. CYLINDERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth fsw | Depth psi | ATA | Rate cu.ft / min | Cylinder psi | Cylinder volume cu.ft | Delivery Pressure depth in psi + 150 psi reg press. | Usable Gas pressure | Usable Gas cu.ft / bottle | Duration Minutes at Depth |
| 1000 | 445.00 | 31.30 | 1.5 | 3500 | 120 | 595.00 | 2905.00 | 99.60 | 2.12 |
| 975 | 433.88 | 30.55 | 1.5 | 3500 | 120 | 583.88 | 2916.13 | 99.98 | 2.18 |
| 950 | 422.75 | 29.79 | 1.5 | 3500 | 120 | 572.75 | 2927.25 | 100.36 | 2.25 |
| 925 | 411.63 | 29.03 | 1.5 | 3500 | 120 | 561.63 | 2938.38 | 100.74 | 2.31 |
| 900 | 400.50 | 28.27 | 1.5 | 3500 | 120 | 550.50 | 2949.50 | 101.13 | 2.38 |
| 875 | 389.38 | 27.52 | 1.5 | 3500 | 120 | 539.38 | 2960.63 | 101.51 | 2.46 |
| 850 | 378.25 | 26.76 | 1.5 | 3500 | 120 | 528.25 | 2971.75 | 101.89 | 2.54 |
| 825 | 367.13 | 26.00 | 1.5 | 3500 | 120 | 517.13 | 2982.88 | 102.27 | 2.62 |
| 800 | 356.00 | 25.24 | 1.5 | 3500 | 120 | 506.00 | 2994.00 | 102.65 | 2.71 |
| 775 | 344.88 | 24.48 | 1.5 | 3500 | 120 | 494.88 | 3005.13 | 103.03 | 2.81 |
| 750 | 333.75 | 23.73 | 1.5 | 3500 | 120 | 483.75 | 3016.25 | 103.41 | 2.91 |
| 725 | 322.63 | 22.97 | 1.5 | 3500 | 120 | 472.63 | 3027.38 | 103.80 | 3.01 |
| 700 | 311.50 | 22.21 | 1.5 | 3500 | 120 | 461.50 | 3038.50 | 104.18 | 3.13 |
| 675 | 300.38 | 21.45 | 1.5 | 3500 | 120 | 450.38 | 3049.63 | 104.56 | 3.25 |
| 650 | 289.25 | 20.70 | 1.5 | 3500 | 120 | 439.25 | 3060.75 | 104.94 | 3.38 |
| 625 | 278.13 | 19.94 | 1.5 | 3500 | 120 | 428.13 | 3071.88 | 105.32 | 3.52 |
| 600 | 267.00 | 19.18 | 1.5 | 3500 | 120 | 417.00 | 3083.00 | 105.70 | 3.67 |
| 575 | 255.88 | 18.42 | 1.5 | 3500 | 120 | 405.88 | 3094.13 | 106.08 | 3.84 |
| 550 | 244.75 | 17.67 | 1.5 | 3500 | 120 | 394.75 | 3105.25 | 106.47 | 4.02 |
| 525 | 233.63 | 16.91 | 1.5 | 3500 | 120 | 383.63 | 3116.38 | 106.85 | 4.21 |
| 500 | 222.50 | 16.15 | 1.5 | 3500 | 120 | 372.50 | 3127.50 | 107.23 | 4.43 |
| 475 | 211.38 | 15.39 | 1.5 | 3500 | 120 | 361.38 | 3138.63 | 107.61 | 4.66 |
| 450 | 200.25 | 14.64 | 1.5 | 3500 | 120 | 350.25 | 3149.75 | 107.99 | 4.92 |
| 425 | 189.13 | 13.88 | 1.5 | 3500 | 120 | 339.13 | 3160.88 | 108.37 | 5.21 |
| 400 | 178.00 | 13.12 | 1.5 | 3500 | 120 | 328.00 | 3172.00 | 108.75 | 5.53 |
| 375 | 166.88 | 12.36 | 1.5 | 3500 | 120 | 316.88 | 3183.13 | 109.14 | 5.88 |
| 350 | 155.75 | 11.61 | 1.5 | 3500 | 120 | 305.75 | 3194.25 | 109.52 | 6.29 |
| 325 | 144.63 | 10.85 | 1.5 | 3500 | 120 | 294.63 | 3205.38 | 109.90 | 6.75 |
| 300 | 133.50 | 10.09 | 1.5 | 3500 | 120 | 283.50 | 3216.50 | 110.28 | 7.29 |
| 275 | 122.38 | 9.33 | 1.5 | 3500 | 120 | 272.38 | 3227.63 | 110.66 | 7.90 |
| 250 | 111.25 | 8.58 | 1.5 | 3500 | 120 | 261.25 | 3238.75 | 111.04 | 8.63 |
| 225 | 100.13 | 7.82 | 1.5 | 3500 | 120 | 250.13 | 3249.88 | 111.42 | 9.50 |
| 200 | 89.00 | 7.06 | 1.5 | 3500 | 120 | 239.00 | 3261.00 | 111.81 | 10.56 |
| 175 | 77.88 | 6.30 | 1.5 | 3500 | 120 | 227.88 | 3272.13 | 112.19 | 11.87 |
| 150 | 66.75 | 5.55 | 1.5 | 3500 | 120 | 216.75 | 3283.25 | 112.57 | 13.53 |
| 125 | 55.63 | 4.79 | 1.5 | 3500 | 120 | 205.63 | 3294.38 | 112.95 | 15.73 |
| 100 | 44.50 | 4.03 | 1.5 | 3500 | 120 | 194.50 | 3305.50 | 113.33 | 18.75 |
| 75 | 33.38 | 3.27 | 1.5 | 3500 | 120 | 183.38 | 3316.63 | 113.71 | 23.16 |
| 50 | 22.25 | 2.52 | 1.5 | 3500 | 120 | 172.25 | 3327.75 | 114.09 | 30.24 |
| 25 | 11.13 | 1.76 | 1.5 | 3500 | 120 | 161.13 | 3338.88 | 114.48 | 43.42 |

## BAILOUT CALCULATIONS FOR 7L CYLINDERS (METRIC)

| Depth msw | Depth Kg/cm² | Bar | Pressure absolute | Rate Ltrs/ Min | Cylinder Bar Luxfer® S080 | Cylinder Bar | Cylinder Kg/cm² Luxfer® S080 | Cylinder Kg/cm² | Cylinder Ltrs FV Luxfer® S080 | Cylinder Ltrs FV Luxfer® 106W | Cylinder Ltrs FV | Cylinder Ltrs at 300 bar Luxfer® S080 | Cylinder Ltrs at 300 bar Luxfer® S106W | Cylinder Ltrs at 300 bar | Delivery Pressure depth in Kg/cm2 +10.54604 Kg/cm2 reg press. | Usable Gas Pressure Luxfer® S080 | Usable Gas Pressure | Usable Gas Ltrs/Cyl Luxfer® S080 | Usable Gas Ltrs/Cyl Luxfer® S106W | Usable Gas Ltrs/ Cyl | Duration Minutes at Depth Luxfer® S080 | Duration Minutes at Depth Luxfer® S106W | Duration Minutes at Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 300 | 30.7692 | 30.1743 | 31.80 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 41.32 | 169.77 | 264.59 | 1997.80 | 3113.79 | 1816.38 | 1.48 | 2.30 | 1.34 |
| 290 | 29.7436 | 29.1685 | 30.77 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 40.29 | 170.79 | 259.71 | 2009.87 | 3056.32 | 1782.85 | 1.54 | 2.34 | 1.36 |
| 280 | 28.7179 | 28.1627 | 29.75 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 39.26 | 171.82 | 260.74 | 2021.94 | 3068.38 | 1789.89 | 1.60 | 2.43 | 1.42 |
| 270 | 27.6923 | 27.1569 | 28.72 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 38.24 | 172.84 | 261.76 | 2034.01 | 3080.45 | 1796.93 | 1.67 | 2.52 | 1.47 |
| 260 | 26.6667 | 26.1511 | 27.70 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 37.21 | 173.87 | 262.79 | 2046.08 | 3092.52 | 1803.97 | 1.74 | 2.63 | 1.53 |
| 250 | 25.641 | 25.1453 | 26.67 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 36.19 | 174.89 | 263.81 | 2058.15 | 3104.59 | 1811.01 | 1.82 | 2.74 | 1.60 |
| 240 | 24.6154 | 24.1394 | 25.65 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 35.16 | 175.92 | 264.84 | 2070.22 | 3116.66 | 1818.05 | 1.90 | 2.86 | 1.67 |
| 230 | 23.5897 | 23.1336 | 24.62 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 34.14 | 176.95 | 265.86 | 2082.29 | 3128.73 | 1825.10 | 1.99 | 2.99 | 1.74 |
| 220 | 22.5641 | 22.1278 | 23.59 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 33.11 | 177.97 | 266.89 | 2094.36 | 3140.80 | 1832.14 | 2.09 | 3.13 | 1.83 |
| 210 | 21.5385 | 21.122 | 22.57 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 32.08 | 179.00 | 267.92 | 2106.43 | 3152.87 | 1839.18 | 2.20 | 3.29 | 1.92 |
| 200 | 20.5128 | 20.1162 | 21.54 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 31.06 | 180.02 | 268.94 | 2118.50 | 3164.94 | 1846.22 | 2.31 | 3.46 | 2.02 |
| 190 | 19.4872 | 19.1104 | 20.52 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 30.03 | 181.05 | 269.97 | 2130.57 | 3177.01 | 1853.26 | 2.44 | 3.64 | 2.13 |
| 180 | 18.4615 | 18.1046 | 19.49 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 29.01 | 182.07 | 270.99 | 2142.64 | 3189.08 | 1860.30 | 2.59 | 3.85 | 2.25 |
| 170 | 17.4359 | 17.0988 | 18.47 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 27.98 | 183.10 | 272.02 | 2154.71 | 3201.15 | 1867.34 | 2.75 | 4.08 | 2.38 |
| 160 | 16.4103 | 16.093 | 17.44 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 26.96 | 184.12 | 273.04 | 2166.78 | 3213.22 | 1874.38 | 2.92 | 4.34 | 2.53 |
| 150 | 15.3846 | 15.0872 | 16.41 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 25.93 | 185.15 | 274.07 | 2178.85 | 3225.29 | 1881.42 | 3.12 | 4.62 | 2.70 |
| 140 | 14.359 | 14.0813 | 15.39 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 24.91 | 186.18 | 275.09 | 2190.92 | 3237.36 | 1888.46 | 3.35 | 4.95 | 2.89 |
| 130 | 13.3333 | 13.0755 | 14.36 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 23.88 | 187.20 | 276.12 | 2202.99 | 3249.43 | 1895.50 | 3.61 | 5.32 | 3.11 |
| 120 | 12.3077 | 12.0697 | 13.34 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 22.85 | 188.23 | 277.15 | 2215.06 | 3261.50 | 1902.54 | 3.91 | 5.75 | 3.36 |
| 110 | 11.2821 | 11.0639 | 12.31 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 21.83 | 189.25 | 278.17 | 2227.13 | 3273.57 | 1909.58 | 4.26 | 6.26 | 3.65 |
| 100 | 10.2564 | 10.0581 | 11.29 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 20.80 | 190.28 | 279.20 | 2239.20 | 3285.64 | 1916.63 | 4.67 | 6.85 | 4.00 |
| 90 | 9.23077 | 9.05229 | 10.26 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 19.78 | 191.30 | 280.22 | 2251.27 | 3297.71 | 1923.67 | 5.16 | 7.56 | 4.41 |
| 80 | 8.20513 | 8.04648 | 9.24 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 18.75 | 192.33 | 281.25 | 2263.34 | 3309.78 | 1930.71 | 5.77 | 8.43 | 4.92 |
| 70 | 7.17949 | 7.04067 | 8.21 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 17.73 | 193.36 | 282.27 | 2275.41 | 3321.85 | 1937.75 | 6.52 | 9.52 | 5.55 |
| 60 | 6.15385 | 6.03486 | 7.18 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 16.70 | 194.38 | 283.30 | 2287.48 | 3333.92 | 1944.79 | 7.49 | 10.92 | 6.37 |
| 50 | 5.12821 | 5.02905 | 6.16 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 15.67 | 195.41 | 284.33 | 2299.55 | 3345.99 | 1951.83 | 8.79 | 12.78 | 7.46 |
| 40 | 4.10256 | 4.02324 | 5.13 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 14.65 | 196.43 | 285.35 | 2311.62 | 3358.06 | 1958.87 | 10.60 | 15.39 | 8.98 |
| 30 | 3.07692 | 3.01743 | 4.11 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 13.62 | 197.46 | 286.38 | 2323.69 | 3370.13 | 1965.91 | 13.31 | 19.31 | 11.26 |
| 20 | 2.05128 | 2.01162 | 3.08 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 12.60 | 198.48 | 287.40 | 2335.75 | 3382.20 | 1972.95 | 17.84 | 25.83 | 15.07 |
| 10 | 1.02564 | 1.00581 | 2.06 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 11.57 | 199.51 | 288.43 | 2347.82 | 3394.27 | 1979.99 | 26.87 | 38.85 | 22.66 |
| 1 | 0.10256 | 0.10058 | 1.13 | 42.5 | 207 | 300 | 211.081 | 305.91 | 12 | 12 | 7 | 2484 | 3600 | 2100 | 10.65 | 200.43 | 289.35 | 2358.69 | 3405.14 | 1986.33 | 49.00 | 70.74 | 41.27 |

| BAILOUT CALCULATIONS FOR 10L CYLINDERS (METRIC) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth msw | Depth Kg/cm² | Bar | Pressure Absolute | Rate Ltrs/Min | Cylinder Bar | Cylinder Kg/cm² | Cylinder Ltrs FV | Cylinder Ltrs at 300 bar | Delivery Pressure depth in Kg/cm² +10.54604 Kg/cm² reg press. | Usable Gas Pressure | Usable Gas Ltrs/ Cyl | Duration Minutes at Depth |
| 300 | 30.7692 | 30.1743 | 31.80 | 42.5 | 300 | 305.91 | 10 | 3000 | 41.32 | 264.59 | 2594.83 | 1.92 |
| 290 | 29.7436 | 29.1685 | 30.77 | 42.5 | 300 | 305.91 | 10 | 3000 | 40.29 | 259.71 | 2546.93 | 1.95 |
| 280 | 28.7179 | 28.1627 | 29.75 | 42.5 | 300 | 305.91 | 10 | 3000 | 39.26 | 260.74 | 2556.99 | 2.02 |
| 270 | 27.6923 | 27.1569 | 28.72 | 42.5 | 300 | 305.91 | 10 | 3000 | 38.24 | 261.76 | 2567.05 | 2.10 |
| 260 | 26.6667 | 26.1511 | 27.70 | 42.5 | 300 | 305.91 | 10 | 3000 | 37.21 | 262.79 | 2577.10 | 2.19 |
| 250 | 25.641 | 25.1453 | 26.67 | 42.5 | 300 | 305.91 | 10 | 3000 | 36.19 | 263.81 | 2587.16 | 2.28 |
| 240 | 24.6154 | 24.1394 | 25.65 | 42.5 | 300 | 305.91 | 10 | 3000 | 35.16 | 264.84 | 2597.22 | 2.38 |
| 230 | 23.5897 | 23.1336 | 24.62 | 42.5 | 300 | 305.91 | 10 | 3000 | 34.14 | 265.86 | 2607.28 | 2.49 |
| 220 | 22.5641 | 22.1278 | 23.59 | 42.5 | 300 | 305.91 | 10 | 3000 | 33.11 | 266.89 | 2617.34 | 2.61 |
| 210 | 21.5385 | 21.122 | 22.57 | 42.5 | 300 | 305.91 | 10 | 3000 | 32.08 | 267.92 | 2627.40 | 2.74 |
| 200 | 20.5128 | 20.1162 | 21.54 | 42.5 | 300 | 305.91 | 10 | 3000 | 31.06 | 268.94 | 2637.45 | 2.88 |
| 190 | 19.4872 | 19.1104 | 20.52 | 42.5 | 300 | 305.91 | 10 | 3000 | 30.03 | 269.97 | 2647.51 | 3.04 |
| 180 | 18.4615 | 18.1046 | 19.49 | 42.5 | 300 | 305.91 | 10 | 3000 | 29.01 | 270.99 | 2657.57 | 3.21 |
| 170 | 17.4359 | 17.0988 | 18.47 | 42.5 | 300 | 305.91 | 10 | 3000 | 27.98 | 272.02 | 2667.63 | 3.40 |
| 160 | 16.4103 | 16.093 | 17.44 | 42.5 | 300 | 305.91 | 10 | 3000 | 26.96 | 273.04 | 2677.69 | 3.61 |
| 150 | 15.3846 | 15.0872 | 16.41 | 42.5 | 300 | 305.91 | 10 | 3000 | 25.93 | 274.07 | 2687.74 | 3.85 |
| 140 | 14.359 | 14.0813 | 15.39 | 42.5 | 300 | 305.91 | 10 | 3000 | 24.91 | 275.09 | 2697.80 | 4.12 |
| 130 | 13.3333 | 13.0755 | 14.36 | 42.5 | 300 | 305.91 | 10 | 3000 | 23.88 | 276.12 | 2707.86 | 4.44 |
| 120 | 12.3077 | 12.0697 | 13.34 | 42.5 | 300 | 305.91 | 10 | 3000 | 22.85 | 277.15 | 2717.92 | 4.79 |
| 110 | 11.2821 | 11.0639 | 12.31 | 42.5 | 300 | 305.91 | 10 | 3000 | 21.83 | 278.17 | 2727.98 | 5.21 |
| 100 | 10.2564 | 10.0581 | 11.29 | 42.5 | 300 | 305.91 | 10 | 3000 | 20.80 | 279.20 | 2738.04 | 5.71 |
| 90 | 9.23077 | 9.05229 | 10.26 | 42.5 | 300 | 305.91 | 10 | 3000 | 19.78 | 280.22 | 2748.09 | 6.30 |
| 80 | 8.20513 | 8.04648 | 9.24 | 42.5 | 300 | 305.91 | 10 | 3000 | 18.75 | 281.25 | 2758.15 | 7.03 |
| 70 | 7.17949 | 7.04067 | 8.21 | 42.5 | 300 | 305.91 | 10 | 3000 | 17.73 | 282.27 | 2768.21 | 7.93 |
| 60 | 6.15385 | 6.03486 | 7.18 | 42.5 | 300 | 305.91 | 10 | 3000 | 16.70 | 283.30 | 2778.27 | 9.10 |
| 50 | 5.12821 | 5.02905 | 6.16 | 42.5 | 300 | 305.91 | 10 | 3000 | 15.67 | 284.33 | 2788.33 | 10.65 |
| 40 | 4.10256 | 4.02324 | 5.13 | 42.5 | 300 | 305.91 | 10 | 3000 | 14.65 | 285.35 | 2798.39 | 12.83 |
| 30 | 3.07692 | 3.01743 | 4.11 | 42.5 | 300 | 305.91 | 10 | 3000 | 13.62 | 286.38 | 2808.44 | 16.09 |
| 20 | 2.05128 | 2.01162 | 3.08 | 42.5 | 300 | 305.91 | 10 | 3000 | 12.60 | 287.40 | 2818.50 | 21.52 |
| 10 | 1.02564 | 1.00581 | 2.06 | 42.5 | 300 | 305.91 | 10 | 3000 | 11.57 | 288.43 | 2828.56 | 32.38 |
| 1 | 0.10256 | 0.10058 | 1.13 | 42.5 | 300 | 305.91 | 10 | 3000 | 10.65 | 289.35 | 2837.61 | 58.95 |

## 10.5 MEDICAL CONDITION REFERENCE CHART

| MEDICAL CONDITION | CAUSE | PREVENTION | SYMPTOMS | TREATMENT |
|---|---|---|---|---|
| **SQUEEZE**<br>Damage done to tissues that do not pressurize with the ambient pressure | G - Gas-filled space<br>R - Rigid walls<br>A - Ambient press. change<br>V - Vascular penetration<br>E - Enclosed space | Stay ahead of the pressure | Dependent upon type of squeeze. | Dependent upon type of squeeze. |
| **HYPOXIA**<br>An $O_2$ deficiency in the body's tissues | - Air supply failure<br>- Diver loses mouthpiece<br>- Airway obstruction or restriction<br>- Insufficient $O_2$ in the diver's breathing media<br>- Inadequate vent in chamber<br>- $O_2$ falls below .16 ATA | - Gas analysis.<br>- Cylinder line-ups.<br>- Pre dive check-outs procedures.<br>- Monitor $O_2$ sensors throughout the dive. | C - Cyanosis (bluing of skin)<br>I - Increased pulse rate<br>L - Lack of muscle control<br>L - Lack of concentration<br>I - Inability to perform delicate tasks<br>W- Weakness<br>L - Loss of consciousness<br>D - Drowsiness | In water:<br>Perform emergency procedure for rig/helmet.<br>Surface:<br>100% $O_2$ by mask.<br>CPR if necessary.<br>Transport to medical facility. |
| **HYPERCAPNIA**<br>($CO_2$ Toxicity)<br>An excess of $CO_2$ built up in the blood | - Skip breathing<br>- Excessive working at depth<br>- Over breathing rig/ helmet<br>- Inadequate lung ventilation<br>- Rig malfunction | - Follow pre dive.<br>- Moderate work pace.<br>- Avoid skip breathing.<br>- Avoid over-breathing diving Apparatus. | I - Increased respiration<br>C - Confusion<br>H - Headache<br>I - Inability to concentrate<br>L - Loss of consciousness<br>D - Drowsiness | In water:<br>- Notify topside.<br>- Decrease work rate.<br>- Breathe normally.<br>- Follow EPs<br>- Abort dive (if necessary).<br>- Seek medical Attention.<br><br>Surface:<br>- Remove diving Apparatus.<br>- Neuro to rule out AGE.<br>- 100% $O_2$ by mask.<br>- Transport to medical facility. |
| **NITROGEN NARCOSIS**<br>A narcotic feeling caused by the effects of inert gasses on the nervous system; usually starts around 4 ATA | Primarily because of $O_2$ toxicity; nitrogen is an inert gas that the body does not use or metabolize | Avoidance of excessive partial pressure of nitrogen.<br>Limit depth.<br>Work up dives. | C - Confusion<br>L - Lack of concern for job or safety<br>A - Apparent stupidity<br>S - Sense of well being<br>I - Impaired judgment | - Ascend above depth of onset<br>- Will normally resolve in :01. |
| **INNER EAR BAROTRAUMA (IEB)**<br>Inner ear contains no gas and is not subject to barotraumas. However, it is located next to the middle ear and affected by the same conditions that produce MIDDLE EAR BAROTRAUMA | - Common cold<br>- Abnormal anatomy<br>- Dysfunctional Eustachian tube<br>- Running nose, head cold or congestion<br>- TYPES: round window rupture, oval window rupture, violent shift in fluid in the inner ear, hemorrhage into inner ear | - Do not perform forceful valsalva maneuver.<br>- No diving with a cold.<br>- Stay ahead of the pressure.<br>- Proper training. | - Vertigo<br>- Hearing loss<br>- Nystagmus<br>- Nausea/ vomiting<br>- Imbalance<br>- Roaring tinnitus<br>- Symptoms of MEB will be Present. | - May be the result of AGE.<br>- Avoid straining.<br>- Transport to medical facility. |

| MEDICAL CONDITION | CAUSE | PREVENTION | SYMPTOMS | TREATMENT |
|---|---|---|---|---|
| **MIDDLE EAR BAROTRAUMA**<br>Most common type of barotrauma (MEB) | - Common cold<br>- Abnormal anatomy<br>- Dysfunctional Eustachian tube<br>- Running nose, head cold, or congestion | - No diving with a cold.<br>- Stay ahead of the pressure.<br>- Proper training. | - Fullness or pain in ear<br>- Slight bloody drip from oral/nasal via cavityEustachian tube<br>- Mild hearing loss | - Notify topside.<br>- Stop travel, ascend/ descend a few feet.<br>- Attempt to clear.<br>- Abort dive if Necessary. |
| **EXTERNAL EAR BAROTRAUMA**<br>Occurs if external auditory canal is blocked | - Wax impaction<br>- Tight wet suit hood<br>- Ear infection | - Pull wet suit hood from face to allow water in and pressurize.<br>- Do not dive with ear infection.<br>- Do not use ear Plugs. | - Canal swelling<br>- Possible hemorrhaging<br>- Considerable pain in the canal | - Transport to medical facility. |
| **CARBON MONOXIDE (CO) TOXICITY**<br>Produced as a result of incomplete combustion of Hydrocarbons | - Compressor intake down-wind of exhaust<br>- Improper compressor oils<br>- Faulty air compressor system | - Do proper pre-dive checks.<br>- Compressor intake located away from engine exhausts.<br>- Proper maintenance of compressors. | - Tightness across forehead<br>- Headache<br>- Nausea<br>- Confusion<br>- Vomiting | - Remove patient from CO exposure.<br>- Neuro to rule out AGE.<br>- 100% $O_2$.<br>- Transport to medical facility |
| **CNS $O_2$ TOXICITY**<br>Central nervous system oxygen toxicity | - Excessive partial pressure usually not encountered unless $PPO_2$ approaches or exceeds 1.6 ATA. However, could be encountered as low as 1.4 ATA. | | VENTID - C<br>V - Visual disturbance<br>E - Ears ringing or roaring<br>N - Nausea<br>T- Tingling/twitching<br>I - Irritability<br>D - Dizziness<br>C - Convulsions | - Off $O_2$.<br>- Wait for symptoms to subside.<br>- Wait :15.<br>- Back on $O_2$ at point of interruption.<br>- Further incidents consult CDP. |
| **AGE**<br>The most serious diving injury; alveolar rupture with air bubbles entering capillaries of the lungs and traveling to the heart and then distributed throughout the body | - Lungs over-inflate, alveolar rupture occurs, and air is forced into the capillaries of the arterial system. These bubbles are carried to the left side of the heart and pumped out the arteries. Bubbles that accumulate in narrow areas create an obstruction of blood flow. All tissue beyond is deprived of blood and turns hypoxic. Damage and symptoms depend on location of blockage. Brain is most significant site for bubbles | - Breath normally.<br>- Never hold your breath on ascent.<br>- If out of air, exhale during ascent. | - Unconsciousness<br>- Weakness<br>- Paralysis<br>- Numbness<br>- Ringing/roaring in ears<br>- Blurred vision<br>- Dizziness<br>- Fatigue<br>- Tingling/twitching<br>Any neurological symptom that presents itself within the first :10 after surfacing from a dive is to be a sign of AGE by non-medical personnel. | - Immediate Recompression.<br>- Complete neuro exam.<br>- 100% $O_2$.<br>- Transport to medical facility below 1,000 ft. above sea level<br>- If patient has relief upon entering chamber, treat original disorder.<br>- Contact certified dive physician. |
| **PULMONARY $O_2$ TOXICITY** | Occurs during long exposures to increased $PPO_2$, causing a direct pulmonary irritant; can occur during treatment tables 4,7,8 and back-to-back TT6 | | C - Coughing, severe<br>B - Breath; shortness of<br>S - Substernal chest pain | - Discontinue $O_2$ Use.<br>- Consult certified diving physician. |

| MEDICAL CONDITION | CAUSE | PREVENTION | SYMPTOMS | TREATMENT |
|---|---|---|---|---|
| **SUBCUTANEOUS EMPHYSEMA** | Results of expansion of gas that is leaked from the mediastinum into the subcutaneous tissues of the neck | | - "Rice Krispies" feeling in neck<br>- Voice change<br>- Symptoms of mediastinal may be present<br>- Feeling of fullness<br>- Difficulty swallowing | - Neuro exam to rule out AGE.<br>- 100% $O_2$.<br>- Consult certified diving physician.<br>- Transport to medical facility. |
| **MEDIASTINAL EMPHYSEMA** | Gas expands and forces gas into the loose mediastinal tissue in the middle of the chest | | - Chest pain behind sternum<br>- Pain may worsen with deep inspiration, coughing or swallowing<br>- Tightness to dull ache from mild to moderate | - Neuro exam to rule out AGE.<br>- 100% $O_2$.<br>- Consult certified diving physician.<br>- Transport to medical facility. |
| **TYPE II DCS** | - Individual variations<br>- Excessive exercise while working<br>- Previous injury<br>- Cold, during decompression<br>- $CO_2$ intoxication<br>- AGE<br>- Alcohol<br>- Dehydration<br>- Fatigue | - Individual variations<br>- Excessive exercise while working<br>- Previous injury<br>- Cold, during decompression<br>- $CO_2$ intoxication<br>- AGE<br>- Dehydration<br>- Fatigue<br>- Ensure proper fitness to dive<br>- Proper training of dive personnel | - Unconsciousness<br>- Weakness<br>- Paralysis<br>- Numbness<br>- Ringing/Roaring in ears<br>- Blurred vision<br>- Dizziness<br>- Fatigue<br>- Tingling/twitching | - Complete Neuro to rule out AGE<br>- Immediate recompression<br>- 100% $O_2$<br>- Contact certified diving physician<br>- Transport to medical facility below 1000 ft. above sea level. |
| **TYPE I DCS** | - Individual variations<br>- Excessive exercise while working<br>- Previous injury<br>- Cold, during decompression<br>- $CO_2$ intoxication<br>- AGE<br>- Alcohol<br>- Dehydration<br>- Fatigue | - Individual variations<br>- Excessive exercise while working<br>- Previous injury<br>- Cold, during decompression<br>- $CO_2$ intoxication<br>- AGE<br>- Alcohol<br>- Dehydration<br>- Fatigue<br>- Ensure proper fitness to dive<br>- Proper training of dive personnel | - Pain<br>- Marbling<br>- Swelling of lymph nodes | - Complete Neuro to rule out AGE or TYPE II.<br>- Immediate recompression.<br>- 100% $O_2$.<br>- Consult certified diving physician<br>- Some forms of TYPE I D.C.S do not require Immediate recompression. |
| **PNEUMOTHORAX**<br>Over–inflation, causing air to enter space between lung and covering and chest wall | - Not exhaling on ascent | - Breathe normally.<br>- Never hold your breath on ascent<br>- Evaluate diver's physical.<br>- Proper training of divers/proper medical screening & functioning equipment. | - Chest pain, lateral or top of shoulder suddenly or sharp<br>- May have rapid or shallow breathing<br>- Diver may guard affected side<br>- Diver may be pale | - Neuro to rule out AGE.<br>- 100% $O_2$.<br>- Contact certified diving physician.<br>- Transport to medical facility. |

## 10.6 ADCI CHECKLIST FOR EQUIPMENT SCHEDULED TESTING AND INSPECTION

| TYPE OF EQUIPMENT | REQUIRED TESTING | RECOMMENDED TESTING | REQUIRED INSPECTION | RECOMMENDED INSPECTION | COMMENTS/NOTES |
|---|---|---|---|---|---|
| Wetsuits | N/A | N/A | N/A | Periodic | |
| Drysuits | N/A | N/A | N/A | Prior to each use | |
| Hot water Suits | N/A | N/A | N/A | Prior to each use | |
| Diving Harnesses | Tested by manufacturer prior to initial use | N/A | N/A | Prior to each use | |
| Weight Belts | N/A | N/A | N/A | Prior to each use | |
| Bailouts | Hydrostatic Test every 5 years | N/A | Annually (by a qualified technician) | N/A | |
| Helmets and Masks | Function Test Annually | Function Test prior to conducting diving operations | Annually (Internal and external) | Inspection prior to conducting diving operations | |
| Breathing Gas Hoses (i.e. Deck Whips and all other LP hoses associated with the breathing gas system) | Pressure Test Annually (Pressure test after initial construction or any modification or repair) | N/A | Annually | Inspection prior to conducting diving operations | |
| Umbilicals | Pressure Test Annually (After initial construction or after any modification or repair) | N/A | Annually | Inspection prior to conducting diving operations | |
| Oxygen Hoses for Life Support | Pressure Test Annually (Pressure test after initial construction or any modification or repair) | N/A | Annually | Inspection prior to conducting diving operations | |
| Compressor Systems | Air Purity Test every 6 months | N/A | N/A | Inspection prior to conducting diving operations | |
| Volume Tanks | Pneumatic Test Annually and Hydrostatic Test every 5 years | N/A | Annually (Internal and external) | Inspection prior to conducting diving operations | |
| Filters | N/A | N/A | N/A | Inspection prior to conducting diving operations | |

| TYPE OF EQUIPMENT | REQUIRED TESTING | RECOMMENDED TESTING | REQUIRED INSPECTION | RECOMMENDED INSPECTION | COMMENTS/NOTES |
|---|---|---|---|---|---|
| Diving Ladder | N/A | N/A | N/A | Inspection prior to conducting diving operations | |
| Stage | N/A | N/A | N/A | Inspection prior to conducting diving operations | |
| PVHO / Chamber | Pressure Leak Test Annually | N/A | Annually (modification or deterioration) | Inspection prior to conducting diving operations | |
| Depth Gauges / Master test Gauges | Calibration every 6 months | N/A | N/A | N/A | |
| Relief Valves | Relief valve pressure setting to be tested annually | N/A | N/A | Periodic | |
| Gas Storage Cylinders / Tubes | Hydrostatic Test every 5 years | N/A | Annually (External and Internal for cylinders used underwater by a qualified technician) | Periodic | |
| Handling Systems | Function Test (When installed, repaired, or modified) | N/A | Visually inspected every 6 months (Damage, deterioration, deformation) | Prior to each job | |
| First Aid Kits | N/A | N/A | Monthly | Prior to each job | |

## 10.7 EMERGENCY RESPONSE DRILLS

**NOTE: The ADCI recommends that companies develop and perform the necessary emergency response drills (ERDs) applicable to their operations. The following drills are examples that can be utilized and/or modified.**

**ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.**

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** ABV/Dizzy on Ascent

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |
| **Key Participants/Remarks:** | |

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | FIRST DIVE AFTER LUNCH. Diver 2 has two holds on descent, with a descent time of 1 minute and 30 seconds. At about 10 feet on ascent, Diver 2 will halt ascent and take about 3 rapid turns around the down line.<br>He/she will report vertigo and will be OK in about 20 seconds at 10 feet. When asked, Diver 2 will state that he/she has just gotten over a cold and took two red Sudafed pills at 0730 that morning in order to be able to dive. The rest of the dive, if controlled, is uneventful. |
| **Table/Schedule:** N/A | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** Actual | |
| **RS:** | |
| **Time of Onset:** Actual | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Diver is recovered and cause is determined.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Launch and Recovery of Emergency Evacuation System (EES)

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

| DIVE PROFILE | SCENARIO |
|---|---|
| *Previous Dive* | **Catastrophic fire has caused the captain to order the emergency evacuation of all personnel from the vessel. Diving personnel in the saturation complex must be transferred to the EES. Launch and recovery of the EES must be initiated.** |
| **Table/Schedule:** | |
| **RS:** | |
| **SI:** | |
| *Current Dive* | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:**

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

## ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Bell-to-Bell Transfer

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |
| **Key Participants/Remarks:** | |

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | During the course of diving operations, the diving bell suffers damage, preventing the transfer lock/TUP from mechanically sealing. A bell-to-bell transfer must be initiated. |
| **Table/Schedule:** | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

| | | | |
|---|---|---|---|
| **Casualty Drill Will Continue Until:** | | | |
| **Start Time:** | **Stop Time:** | | |
| **Symptoms presented as briefed? (If not, explain in remarks.)** | | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** $CO_2$ Buildup (In Demand-type Breathing Rig)

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

Communications/Log Keeper, Diving Supervisor, Standby Diver (if deployed), Tenders.

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **Diver has $CO_2$ buildup approximately 15 minutes into the dive. Symptoms are light-headedness, breathing hard and irritability, and eventually, diver passes out if proper action is not taken. Once diver is ventilated, the dive continues normal.** |
| **Table/Schedule:** None | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Diver is ventilated.

| | | | |
|---|---|---|---|
| **Start Time:** | | **Stop Time:** | |
| **Symptoms presented as briefed? (If not, explain in remarks.)** | | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. **Poor/Wrong Procedures/Major Safety Violations**
2. **Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor**
3. **Average/No Safety Violations/Required Some Prompting by Supervisor**
4. **Above Average/No Safety Violations/Required Minimal Prompting by Supervisor**
5. **Outstanding/No Safety Violations/Required No Prompting by Supervisor**

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Contaminated Breathing Gas Supply

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

Diving supervisor, communications/logs operator, tender, standby diver (if deployed).

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **Approximately 10 minutes into the dive, the diver says the air tastes funny. If no action is taken, within 3 minutes the diver will pass out. If or when the diver shifted to EGS or a backup breathing gas source, the taste goes away. The diving supervisor *MUST* send someone to inspect the primary breathing source of problems.** |
| **Table/Schedule:** NONE | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Breathing gas source is shifted.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. **Poor/Wrong Procedures/Major Safety Violations**
2. **Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor**
3. **Average/No Safety Violations/Required Some Prompting by Supervisor**
4. **Above Average/No Safety Violations/Required Minimal Prompting by Supervisor**
5. **Outstanding/No Safety Violations/Required No Prompting by Supervisor**

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

**ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.**

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** DCS/Type I/Pain in Right Elbow

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **During the last dive of the day, Diver 2 from the previous dive informs a fellow member of the dive team that his/her right elbow is very sore. When asked, he/she will state that it started at about 30 minutes after surfacing. It is not aggravated with movement and not a result of any mechanical injury. It is about a 7 on a 1 to 10 scale, up from about a 4 when first noticed. There are no other symptoms. Symptoms will completely resolve on descent in the chamber.** |
| **Table/Schedule:** 60'/55 minutes | |
| **RS:** | |
| **SI:** 45 minutes | |
| ***Current Dive*** | |
| **Table/Schedule:** Actual | |
| **RS:** | |
| **Time of Onset:** @ 30 minutes SI | |
| **Project:** | |

**Casualty Drill Will Continue Until:** At 60 feet in, the chamber and correct TT determined.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. **Poor/Wrong Procedures/Major Safety Violations**
2. **Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor**
3. **Average/No Safety Violations/Required Some Prompting by Supervisor**
4. **Above Average/No Safety Violations/Required Minimal Prompting by Supervisor**
5. **Outstanding/No Safety Violations/Required No Prompting by Supervisor**

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

**ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.**

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** DCS/Type II/Pain Left Forearm, Numbness Left Hand

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |
| **Key Participants/Remarks:** | |

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **During the last dive of the day, Diver 2 from the previous dive reports to a fellow member of the dive team that his/her left forearm hurts somewhat. When asked, he/she will state that it started about 15 minutes surface interval (SI) while he/she was in the shower. The pain will be hard to pinpoint and is not made worse by movement. It is at a 6 on a 1 to 10 scale and has gotten a little worse since first noticed. During a neuro, numbness is found on the back of the left hand. Diver will be asymptomatic at 11 minutes into the first $O_2$ period.** |
| **Table/Schedule:** 70'/50 minutes | |
| **RS:** | |
| **SI:** 30 minutes | |
| ***Current Dive*** | |
| **Table/Schedule:** Actual | |
| **RS:** | |
| **Time of Onset:** @15 minutes SI | |
| **Project:** | |

**Casualty Drill Will Continue Until:** 11 minutes @ 60' and the Proper TT is determined.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. **Poor/Wrong Procedures/Major Safety Violations**
2. **Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor**
3. **Average/No Safety Violations/Required Some Prompting by Supervisor**
4. **Above Average/No Safety Violations/Required Minimal Prompting by Supervisor**
5. **Outstanding/No Safety Violations/Required No Prompting by Supervisor**

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Diver Shocked While Underwater Welding

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

Communications/logs operator, diving supervisor, tenders, switch operator, standby diver (if deployed).

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **While welding underwater, the diver reports being shocked. The topside personnel should disconnect the knife switch. If power is not secured in a timely manner, the diver will become unconscious (not answering communications or line-pull signals).** |
| **Table/Schedule:** NONE | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Power to the welding equipment is secured

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

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ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Fouled Diver, Hose Change

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

Standby Diver, Tenders, Phone Talker, Dive Supervisor

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **Diver fouled on bottom and is unable to become free. When asked, the diver states he/she is wrapped around the downline several times and cannot tell which way to move to become free. Standby will be deployed but is unable to clear the diver and will state that the umbilical needs to be changed out with another umbilical from the surface. Standby will acquire another umbilical and change out umbilicals on the primary diver.** |
| **Table/Schedule:** N/A | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Umbilical is changed out in the water.

| | | | |
|---|---|---|---|
| **Start Time:** | **Stop Time:** | | |
| **Symptoms presented as briefed? (If not, explain in remarks.)** | | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. **Poor/Wrong Procedures/Major Safety Violations**
2. **Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor**
3. **Average/No Safety Violations/Required Some Prompting by Supervisor**
4. **Above Average/No Safety Violations/Required Minimal Prompting by Supervisor**
5. **Outstanding/No Safety Violations/Required No Prompting by Supervisor**

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ADCI

## ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Mechanical, Badly Sprained Right Ankle

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | While returning to the down line, Diver 1's right foot gets fouled in debris on the bottom. He/she does not report this. The tenders will continue to take up slack until Diver 1 lets out a yell to stop. Diver 1 reports that his/her foot is clear but got severely twisted in the process. When asked, Diver 1 will state that he/she can make it to the down line but will require assistance up the ladder. |
| **Table/Schedule:** N/A | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** Actual | |
| **RS:** | |
| **Time of Onset:** Bottom | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Injured diver is on deck and recommendation made.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** POIS/AGE/Pneumothorax, Weakness

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |
| **Key Participants/Remarks:** | |

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | LAST DIVE OF THE DAY. During cleanup, Diver 1 from the last set complains of a moderate pain on the left lateral side of his/her chest that started about 11 minutes after surfacing from the dive. It hurts more when inhaling but is not getting worse. Reports a 6 on a 1 to 10 scale. Neuro reveals notable weakness in the diver's left shoulder, when he/she is asked to shrug shoulders. There are no other symptoms. Diver will be asymptomatic 5 minutes after reaching treatment depth. |
| **Table/Schedule:** N/A | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** Actual | |
| **RS:** | |
| **Time of Onset:** @ 15 minutes SI | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Diagnosis, treatment depth and TT determined.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** POIS/Mediastinal/Pain, Cough

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |
| **Key Participants/Remarks:** | |

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **LAST DIVE BEFORE LUNCH. Upon reaching surface, Diver 1 starts to cough. When unhatted, he/she will complain of a burning sensation and pain in the center of his/her chest that is worse when taking a deep breath. The cough gets slightly worse and persists. A neuro reveals no other symptoms.** |
| **Table/Schedule:** N/A | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** Actual | |
| **RS:** | |
| **Time of Onset:** @ RS | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Neuro and proper diagnosis and treatment are made.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Tender Collapses Due to Heat Exhaustion

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

Dive supervisor, tenders, extra personnel on the side.

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **Shortly after the diver enters the water (approximately 10 minutes), the No. 1 tender will pass out. Upon further investigation, it is discovered that this tender is suffering from heat exhaustion.** |
| **Table/Schedule:** NONE | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Tender is given appropriate first aid.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. **Poor/Wrong Procedures/Major Safety Violations**
2. **Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor**
3. **Average/No Safety Violations/Required Some Prompting by Supervisor**
4. **Above Average/No Safety Violations/Required Minimal Prompting by Supervisor**
5. **Outstanding/No Safety Violations/Required No Prompting by Supervisor**

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Unconscious Penetration Diver

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

Dive supervisor, communications/logs operator, standby diver, tenders.

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **Shortly after entering the penetration area (at least 10 feet but not more than 15 feet), the diver stops and does not answer communications or line-pull signals. Standby has to rescue diver.** |
| **Table/Schedule:** NONE | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Unconscious Diver is on the dive platform.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. **Poor/Wrong Procedures/Major Safety Violations**
2. **Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor**
3. **Average/No Safety Violations/Required Some Prompting by Supervisor**
4. **Above Average/No Safety Violations/Required Minimal Prompting by Supervisor**
5. **Outstanding/No Safety Violations/Required No Prompting by Supervisor**

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Unconscious Tender

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

Diving supervisor, tenders, extra personnel on the side.

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | **Shortly after the diver enters the water (approximately 10 minutes), the No. 1 tender will pass out. Upon further investigation, it is discovered that this tender made the *previous* dive.** |
| **Table/Schedule:** NONE | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:** Tender is at correct treatment depth.

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. **Poor/Wrong Procedures/Major Safety Violations**
2. **Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor**
3. **Average/No Safety Violations/Required Some Prompting by Supervisor**
4. **Above Average/No Safety Violations/Required Minimal Prompting by Supervisor**
5. **Outstanding/No Safety Violations/Required No Prompting by Supervisor**

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Unconscious Bell Diver (in the Bell)

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | After repeated attempts by diving control to contact the bell, the diver was directed to return to the bell, to discover the bell man unconscious. Unconscious bell siver (in the bell) response procedure initiated. |
| **Table/Schedule:** | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:**

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Unconscious Bell Diver (Out of the Bell)

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |

**Key Participants/Remarks:**

| DIVE PROFILE | SCENARIO |
|---|---|
| ***Previous Dive*** | After failing to respond to radio communications from dive control, the bell, and line pulls from the bell, the Bell Standby was sent to the location of the diver. Initiate unconscious bell diver response procedure. |
| **Table/Schedule:** | |
| **RS:** | |
| **SI:** | |
| ***Current Dive*** | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

**Casualty Drill Will Continue Until:**

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Loss of Breathing Media to Diver

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |
| **Key Participants/Remarks:** | |

| DIVE PROFILE | SCENARIO |
|---|---|
| *Previous Dive* | While diver was working on the bottom, delivery of diver's primary breathing gas was interrupted. Supervisor needs to initiate emergency gas to diver and resolve primary gas failure. |
| Table/Schedule: | |
| RS: | |
| SI: | |
| *Current Dive* | |
| Table/Schedule: | |
| RS: | |
| Time of Onset: | |
| Project: | |

| | | | |
|---|---|---|---|
| **Casualty Drill Will Continue Until:** | | | |
| **Start Time:** | **Stop Time:** | | |
| **Symptoms presented as briefed? (If not, explain in remarks.)** | | YES | NO |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

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## ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

| **Category/Type/Symptom:** Hydrocarbons in the Bell | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |
| **Key Participants/Remarks:** | |

| DIVE PROFILE | SCENARIO |
|---|---|
| *Previous Dive* | **Hydrocarbon alarm in the bell has gone off. Hydrocarbons response procedure initiated.** |
| **Table/Schedule:** | |
| **RS:** | |
| **SI:** | |
| *Current Dive* | |
| **Table/Schedule:** | |
| **RS:** | |
| **Time of Onset:** | |
| **Project:** | |

| **Casualty Drill Will Continue Until:** | | | |
|---|---|---|---|
| **Start Time:** | **Stop Time:** | | |
| **Symptoms presented as briefed? (If not, explain in remarks.)** | | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

ASSOCIATION OF DIVING CONTRACTORS INTERNATIONAL, INC.

# EMERGENCY RESPONSE DRILLS

**Category/Type/Symptom:** Recovery of Unconscious Surface Diver

| | |
|---|---|
| **Supervisor:** | **Job No.** |
| **Subject:** | **Date:** |
| **Key Participants/Remarks:** | |

| DIVE PROFILE | SCENARIO |
|---|---|
| *Previous Dive* | After no response from the diver via radio communication or line pulls, the standby was sent down to the diver's location. Standby diver reports the diver unconscious. Unconscious diver response procedure to be initiated. |
| Table/Schedule: | |
| RS: | |
| SI: | |
| *Current Dive* | |
| Table/Schedule: | |
| RS: | |
| Time of Onset: | |
| Project: | |

**Casualty Drill Will Continue Until:**

| | |
|---|---|
| **Start Time:** | **Stop Time:** |

| | | |
|---|---|---|
| **Symptoms presented as briefed? (If not, explain in remarks.)** | **YES** | **NO** |

**Grade Casualty Drill with 1-5 or N/A as follows:**

1. Poor/Wrong Procedures/Major Safety Violations
2. Below Average/Minor Safety Violations/Required Frequent Prompting by Supervisor
3. Average/No Safety Violations/Required Some Prompting by Supervisor
4. Above Average/No Safety Violations/Required Minimal Prompting by Supervisor
5. Outstanding/No Safety Violations/Required No Prompting by Supervisor

| ITEM / AREA | GRADE | ITEM / AREA | GRADE |
|---|---|---|---|
| • Recognized Initial Problem | | • Questions Asked | |
| • Notified the Company Office | | • Dive Profile Checked | |
| • Notified Emergency Services | | • Dive Partner Checked | |
| • Dive Stations Covered | | • Surface $O_2$ – Stretcher on Scene | |
| • Emergency Assignments | | • Correct Diagnosis of Symptom | |
| • Dive Team Efforts | | • Correct Treatment Table | |
| • Standby Diver Deployed | | • Correct Depth | |
| • Control of Injured Personnel | | • Travel Rate | |
| • Neurological Exam | | • Post Treatment | |
| • Affected Area Checked | | • Other | |

**Supervisor's Debrief:**

**Participants' Remarks:**

## 10.8 VENOMOUS FISH STINGS

| VENOMOUS FISH STINGS | |
|---|---|
| **PATIENT CRITERIA:** | Stings from venomous fish include lionfish, scorpionfish, and stonefish. Stings that occur in waters with poor visibility and known to have venomous fish envenomation and treated accordingly to this protocol. While there has been no cases reported in the medical literature of anaphylaxis secondary to lionfish there is a posiibility that this may occur after repeated exposures. Anaphylaxis protocols should be followed for symptoms consistent with anaphylaxis. Mild to severe pain may be reported at the sight of the puncture wound. Venomous fish toxins are of the neuromuscular type and can cause a variety of other systemic symptons including headache, nausea, vomiting, abdominal pain or cramping, delirium, seizures limb paralysis, hyper or hypotension, respiratory distress, dysrhythmia, myocarial ischemia, congestive heart failure, pulmonary edema, tremors, muscle weakness and syncope. Pain that worsens hours or days after initial improvement with hot water treatment may indicate secondary infection. Although painful, local treatment with hot water generally relieves pain in most cases. |
| **REQUIRED ASSESSMENT:** | • Focused History & Physical to include vital signs.<br>• Examination of the skin for puncture wounds and/or vesicle.<br>• Auscultation of Lung sounds for wheezing or stridor.<br>• Document locaton, distribution of skin lesions and obtain full history of event and any similar pasts.<br>• Measure areas of redness or swelling and record for future reference.<br>• Strength testing and sensory testing. |
| **INTERVENTION:** | • Currently there is antivenin for stonefish and it is available only in the Indo Pacific region. If in a region where antivenin is available and the injury is thought to be secondary to stonefish or scorpionfish, consider transport to a facility where it may be administered.<br>• The venom found in these fish is heat labile and generally responds to hot water treatment. If on an extremity that can be immersed, heat water toa temperature of 113 degrees Farenheit (45 degrees Celcius). Ideally measured with a thermometer and immerse the extremity in the water for 15 minutes at at time. Otherwise soak towels in hot water and apply them to the areas affected..<br>• Treatment with hot water may be repeated.<br>• If fish spines are suspected to be present in the tissues, call the medical consultant for further instuction.<br>• Clean the wound wit providone iodine (betadine) and dress with mupirocin or triple antibiotic ointment if mupirocin is unavailable..<br>• **Treatment of mild to moderate pain:** Ibuprofen 400mg PO q.i.d or Acetaminophen 1,000mg PO q.i.d.<br>• **Update diphtheria/tetanus as needed.** |
| **ALS:** | **Contact Medical Consultant prior to administering Antibiotics or Narcotics.**<br>• **Pain unresponsiv to non-steroidal anti-inflammatory agents:** IMay escalate Ibuprofen to 800mg PO q.i.d with unresolving symptoms. If no change in symptoms after administering Ibuprofen, narcotic analgesics may be considered. |
| **CLINICAL CONSIDERATIONS:** | **Contact Medical Consultant prior to administering Antibiotics or Narcotics.**<br>• **Secondary infection:** Consider antibiotic treatment with Doxycycline 100mg bid/Sulfa 160/800 mg bid for 10 days.<br>• **Anaphylaxis:** Treat according to standard anaphylaxis protocols using epinephrine (Epipen) and repeat if ecessarybid for 10 days. |
| **CONSULTATION & REFERRAL CRITERIA:** | • Transport will be required for those patients who present with severe syptoms, fever or for those that have pain not responsive to oral maediction.<br>• Transport will be required for those patients that have signs of necrosis.<br>• Transport may be required for those patients who retained fish spines.<br>• Transport will be required for areas wher antivenim is available for the treatment of symptoms due to stonefish or scorpionfish. |

## 10.9 JOB HAZARD ANALYSIS

JOB HAZARD ANALYSIS

| | | | | |
|---|---|---|---|---|
| Company: | Location: | Date: | Page_____of_____ | New ❐<br>Revised ❐ |
| Job or Task: | | | | |
| No. | Basic Job Steps | Potential Hazards | Recommended Safe Procedures/Protection | Responsibilty |
| | | | | |
| Prepared By: | | Reviewed By: | | Approved By: |
| Distribution: | | | | |

## 10.10 REFERENCE MATERIAL

### Volume Tank Test Procedure

*All volume tanks and associated piping shall be pneumatically tested annually to the MAWP of the system. A hydrostatic test to 1.3 MAWP is to be done every fifth year or after any repair, modification or alterations to the pressure vessel.*

**Ensure you fully read and understand all directions before starting**

1. Visually inspect the entire exterior of the volume tank to be tested for any noticeable damage or corrosion, pay close attention to the areas around the fittings for cracks.

2. Check last hydro date and ensure that hydro test is current (every fifth year).

3. Remove, inspect and test the non-return valve for proper operation. Blow air one way, no flow the other way. Reinstall non-return valve, ensuring proper flow direction.

4. Remove and inspect pressure relief valve (See Pressure Relief Valve Test Procedures). Depending on the pop off setting of this valve, removal and plugging may be necessary for pneumatic test. All pressure relief valves must be set and "crack" at no more than 10% ABOVE MAWP.

5. Inspect pressure gauge for any defects and replace/recalibrate as needed.

6. Inspect drain valve and ensure proper function.

7. Remove inspection plug and inspect tank interior for dirt, oil and corrosion.

8. Clean tank interior of debris, oil and rust with simple green and fresh water. Once interior has been cleaned and dried reinstall inspection plugs.

9. If significant corrosion or defects are found bring this to the attention of a supervisor.

10. Pressurize the system, tanks and piping to MAWP stamped on plate.

11. Check the system for leaks at all connections, penetrations, valves, and gauges using a mixture of soapy water.

12. Depressurize the system.

13. Document any tests (pass or fail) and or repairs made in the equipment log file.

14. Make sure the test records form is properly filled out and turned into the equipment log.

## Volume Tank 5-Year Hydrostatic Test Procedure

*All volume tanks and associated piping shall be pneumatically tested annually to the MAWP of the system. A hydrostatic test to 1.3 MAWP is to be done every fifth year or after any repair, modification or alterations to the pressure vessel.*

**Ensure you fully read and understand all directions before starting**

1. Visually inspect the entire exterior of the volume tank to be tested for any noticeable damage or corrosion, pay close attention to the areas around the fittings for cracks.

2. Check last hydro date. This test is only required every five years.

3. Remove all plumbing and plug all holes except one on top.

4. Remove inspection plug and inspect the volume tank interior for dirt, oil and corrosion.

5. Clean the volume tank interior of debris, oil and rust with simple green and fresh water. Once interior has been cleaned, reinstall inspection plugs.

6. If significant corrosion or defects are found bring this to the attention of a supervisor.

7. Plug the volume tank and fill "completely" with water.

8. Pressurize the volume tank to 1.3 times MAWP stamped on plate. Hold for 10 minutes. Decrease pressure to MAWP.

9. Check the volume tank for leaks at all penetrations.

10. Depressurize the volume tank.

11. Drain and Dry the volume tank and re-install all hardware.

12. Pressurize with air to MAWP and check for leaks.

13. Document any tests (pass or fail) and or repairs made in the equipment log file.

14. Make sure the test records form is properly filled out and turned into the equipment log.

## Commercial SCUBA Pre and Post Dive Checklist

| | |
|---|---|
| **Project name/number/location** | |
| **Date:** | **Diving Supervisor** |
| **Team assignments (four person minimum)** | |
| **Diving Supervisor** | |
| **Diver 1** | |
| **Diver 2** | |
| **Standby Diver** | |
| **Tender** | |

| | Diver 1 | Diver 2 | Standby |
|---|---|---|---|
| **All equipment service dates with in one year except hydro.** | | | |
| **Air Cylinders (Primary Bottles AND Bailout Bottles)** | | | |
| Cylinder - Verify current hydro and VIP | | | |
| O-Ring and valve - Verify in good condition | | | |
| Bailout pressure - calculated for 5-minute minimum at max depth | | | |
| Primary Pressure - Verify adequacy for operations | | | |
| **Buoyancy Compensator (BC)** | | | |
| Straps / buckles / harness - in good condition and adjusted for fit | | | |
| Air bladder - leak check | | | |
| Cylinder and bailout - mount securely | | | |
| Inflator fitting and hose - in good condition | | | |
| BC Inflation - check proper function | | | |
| Dump valves - check for proper function | | | |
| **Regulator(s) & Hoses** | | | |
| Hoses / Connectors - in good condition | | | |
| Primary and Bailout 1st - in good condition | | | |
| Octopus second stage if used - in good condition | | | |
| Primary and bailout routed through switchside / side block | | | |
| Switch / side block operating properly | | | |
| Switch / side block secured to harness | | | |
| Regulator assemblies - attach to appropriate cylinders | | | |
| Primary regulator / bailout regulator - test | | | |
| Valves - open / Leak check cylinder O-ring | | | |
| Inflation whip - attach to BC | | | |
| Dry suit whip - attach to BC | | | |
| Check pressure fittings for leaks | | | |
| **Pressure Gauge** | | | |
| Verify gauges on primary and bailout reading is properly - Note tank pressure for Dive Log | | | |
| Re-set Maximum Depth Indicator to zero | | | |
| **Coms** | | | |
| Topside new batteries or power supply | | | |
| Transducer proper deployed | | | |
| Divers ear and mic set properly mounted to the full face mask | | | |

| | | | |
|---|---|---|---|
| Divers ear and mic set, new batteries or full charge | | | |
| Check proper setting | | | |
| **Emergency Gas Supply (Alternate Air Source)** | | | |
| Securel mounted; All connections verified | | | |
| Bailout operations check; Verify cylinder is OPEN and closed at the switch side block | | | |
| **Diver** | | | |
| Thermal / general protective clothing - Comfortable for planned duation | | | |
| Face Mask - faceplate / seal / straps | | | |
| Fins - blades / pocket / straps / locks | | | |
| Knife - sharp / scabbard / straps secure | | | |
| Weight Belt - quick release / weights adequate and secure | | | |
| If an octopus is in use, check and secure it to the divers harness | | | |
| Watch - time set / strap secure | | | |
| **Miscellaneous** | | | |
| Ladder - rigging secure, bottom rung 3 ft. below planner low water | | | |
| Tending Line - flaked out, terminus tied off | | | |
| Tools - in good condition, set at entry point | | | |
| Camera - checked, loaded, set at entry point | | | |
| **Lost diver bouy checked and ready for deployment** | | | |
| **Diver Extraction Device** - verify devise (e.g.TRIDE) is set up and functions properly | | | |
| **Publications** - Decompression tables, dive logs, dive manual scope of work at | | | |
| **Flags** - Decompression tables, dive logs, dive manual scope of work at | | | |
| **Notifications** - Required agency and facility contacts made | | | |
| **In water checks** | | | |
| Leak all equipment | | | |
| Air | | | |
| Coms check all divers and topside | | | |
| **Post - Dive Checklist** | | | |
| Note tank pressure. Shut valve and bleed off regulator | | | |
| Disassemble dive spread, clean and stow all equipment | | | |
| Note any equipment issues | | | |

**Checker to initial when complete:**

Complete all applicable documents

## Pressure Relief Valve Test Procedure

*All Pressure Relief Valves (PRV) shall be tested annually to the MAWP of the system or after any repair, modification, alterations to the PRV or before original installation.*

**Ensure you fully read and understand all directions before starting**

1. Remove Pressure Relief Valve (PRV) from the piece of equipment it was on. Visually inspect. Record the setting stamped on the PRV.

2. Connect PRV to the output side of PRV testing apparatus.

3. Connect the input side of the PRV to a regulated high pressure air source iwth a 3/8 inch deck whip.

4. Slowly increase air pressure from zero up to the PRV pop-off setting or as needed PRV should release. Make note of the release pressure.

5. Bleed off air pressure until PRV resets. Repeat to verify release pressure.

6. If PRV fails, replace with a new PRV and report to supervisor. **All pressure relief valves should be set at no more than 10% above MAWP.**

7. If no replacement is necessary, place the PRV back onto the piece of equipment it was on, being sure to you use Teflon tape.

8. Document any tests (pass or fail) and or repairs made in the euipment log file.

9. Make sure the test records form is properly filled out and turned into the equipment log

10. Apply sticker or tag to body of relief valve depicting test date, due date, cracking pressure and technician's initials.

## Decompression Chamber Pressure Test Procedure

*Pressure testing is to be performed on the Recompression Chamber when it is newly installed, when repairs are made and on an annual basis.*

Tests and test results are recorded on a standard Double Lock Recompression Chamber Air Pressure and Leak Test form (see form).

**Ensure you fully read and understand all directions before starting**

1. Pressurize the inner lock to 135 PSI (MAWP). Check for leaks at all points of penetration: fittings, view-ports, dog seals, valve connections, pipe joints, and shell weldments, with either soapy water or an evaluation solution.

2. Mark all leaks.

3. Depressurize the lock and make whatever adjustments or repairs are necessary to seal the leaks.

4. Repeat Steps 1-3 as necessary until all leaks are eliminated.

5. Pressureize to 225 fsw (100 psig or Chamber MAWP) and hold for 5 minutes.
   **DO NOT exceed maximum pressure rating for the pressure vessel (MAWP 135 PSI)**

6. Depressurize the lock to 165 fsw (73.4 psig), Hold for 1 hour. If pressure drops below 145 fsw (65 psig), locate and mark all leaks as above and repeat steps 5 and 6. Repeat as necesssary until ending pressure is at least 145 fsw (65 psig).

7. Repeat steps 1 through 6 leaving the inner door open and outer door closed. Leak test those portions of the which have not yet been tested.

**LEAKS:**

**View-port leaks:** remove the gasket and clean or replace if necessary.

IMPORTANT

- Acrylic view-ports should not be lubricated. They should not cone in any contact with and lubricants, volatile detergent or leak detector. Always use non-ionic detergent for the leak test.

  When reinstalling the view-port do not over compress the gasket. Take up retaining ring bolts just until the gasket compresses evenly around the port.

**Weldment leaks:** Contact the appropriate technical authority for assistance.

# Notes

# Notes

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# Notes