UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

Safety Standards for Human Occupied Vehicles

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SAFETY STANDARDS
for
HUMAN OCCUPIED VEHICLES

The Safety Standards for Research Human Occupied Vehicles (HOVs) were drafted by a University-National Oceanographic Laboratory System (UNOLS) subcommittee and were adopted by the UNOLS Council in March 2009. The subcommittee members are listed below. These safety standards provide guidelines for the operation of oceanographic research submersibles owned, operated or chartered by Members of the University-National Oceanographic Laboratory System (UNOLS), to assure that research at sea is conducted to the highest practicable standards of safety and prudence. Each Member is encouraged to comply with them as applicable to all submersibles under his or her control. Non-UNOLS operators of research HOVs are invited to make use of them as well.

HOV Safety Standards Subcommittee Membership:

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Cover photos (credits are shown in parenthesis) - clockwise from upper left: *Pisces V* (HURL), *Alvin* recovery (WHOI), *Pisces V* on support ship R/V *Ka'imikai-O-Kanaloa*'s *(HURL)*, *Alvin* (WHOI), and *Johnson-Sea-Link* on support ship R/V *Seward Johnson* (HBOI/FAU)

SAFETY STANDARDS
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HUMAN OCCUPIED VEHICLES

1. INTRODUCTION

Marine science researchers have employed submersibles as effective platforms for oceanographic observations, collections, and experiments for several decades. These safety standards provide guidelines for the operation of research Human Occupied Vehicles (HOVs) operated or chartered by Members of the University-National Oceanographic Laboratory System (UNOLS), to assure that submergence research at sea is conducted to the highest practicable standards of safety and prudence. Each Member Institution is encouraged to comply with them as applicable to the HOVs under their control. Specific use of these standards shall be set forth under the terms of the user's charter and made to meet the unique characteristics of each vehicle. Non-UNOLS operators of HOVs are invited to make use of them as well.

Currently, the National Deep Submergence Facility (NDSF) at Woods Hole Oceanographic Institution (WHOI) operates the HOV *Alvin*, Harbor Branch Oceanographic Institution/Florida Atlantic University (HBOI/FAU) operates two *Johnson Sea-Link* submersibles and the *Deep Workers*, and the Hawaii Undersea Research Laboratory (HURL) operates two deep-diving submersibles, *Pisces IV* and *Pisces V*. These standards have been developed in consultation with the operators and users of these HOVs. The terms "Human Occupied Vehicles" and "Submersibles" are used interchangeably throughout this document.

Safety of both the personnel diving in the HOV and of individuals aboard the support ship is paramount in establishing the operating procedures under which human occupied submersibles support science research missions. Over many years of experience, institutions operating HOVs have developed checklists, personnel training manuals, testing procedures, maintenance intervals, and safety review protocols. As the state-of-the-art technology advances, conscientious operators have kept pace by continually improving their systems in relevance and utility for the science users, in training of operational personnel, and in safety.

An HOV system consists of three major components: the undersea vehicle, the submersible support surface platform, and the handling system that moves the submersible across the air/water interface. Regulatory agencies and experienced operators worldwide focus on the essential synergy of these three elements to provide an effective and safe tool for undersea research and exploration.

HOVs that are operated from UNOLS vessels must meet all applicable inspection standards and be currently certified by the American Bureau of Shipping (ABS), U.S. Navy, or other such body recognized for that purpose within established regulatory compliance regimes. These safety standards provide guidelines for the operation of oceanographic research HOVs to assure that research at sea is conducted to the highest practicable standards of safety and prudence. These standards are based in major part on applicable regulations. Nothing herein is intended to conflict with the legal standards, but rather to encourage and assist the operator to not only meet, but exceed the legal minimums, as may be desirable and practicable.

2. DEFINITIONS AND ACRONYMS

2.0 INTRODUCTION

Terms and acronyms used in this document are defined below.

2.1 DEFINITIONS

- Ballast System – Method used for controlling or varying the weight or displacement of a submersible.
- Chief Scientist – The designated member of the scientific party who is in overall charge of the research operations on board ship. The Chief Scientist is responsible for the coordination and execution of the entire scientific mission, not just her or his own portion of it. The Chief Scientist works closely with the Expedition Leader (or Submersible Operations Director/Coordinator) to develop an acceptable mission plan that includes location, depth, tasks, equipment and personnel required. In matters of operational safety, the Chief Scientist must always defer to the Master of the vessel, the Expedition Leader, or the pilot of the vehicle.
- Expedition Leader - The Expedition Leader, also referred to as Submersible Operations Coordinator or Submersible Operations Director, is responsible for the safe and efficient operation of the submersible and its associated systems. The Expedition Leader is the liaison between the Master of the vessel and the Chief Scientist and ensures that the submersible is ready in all respects for diving operations at the appointed time. The Expedition Leader is responsible for maintaining an overview of the entire operation to avoid conflicting demands and works closely with the Master in coordinating all efforts. Throughout this document, the title “Expedition Leader” will be used to refer to the Submersible Operations Director, Coordinator, or Expedition Leader.
- Handling System – The means by which a Human Occupied Vehicle (HOV) is transferred from the deck of the support vessel into the water and, conversely, retrieved from the water to the deck of the support vessel.
- Human Occupied Vehicle – A vehicle designed to carry people under the surface of the water. Also referred to as a submersible.
- Human-rated – A term used to describe the certification of a submersible or handling system as worthy of transporting humans. The human-rating certification is an assurance that the engineering, health, and safety features of the system will prevent fatal or permanently disabling injuries to occupants.
- Life-Support System – Equipment provided within a submersible for the purpose of sustaining the lives of the occupants.
- Master – The designated member of the crew of a vessel who is in legal overall charge of the entire operation of the vessel. The term "Captain" is used almost interchangeably. Under United States law and International treaty, the ship's Master is solely and ultimately responsible for the safety and good conduct of the ship and all persons embarked, including the scientific party.
- Observer – Scientist or other individual in the HOV who is not part of the submersible crew.
- Operations Manual - Written document that defines how the submersible is maintained and

operated.

- Pilot – Individual in direct control of the submersible operation and safety during the dive.
- Objective Quality Evidence (OQE) – The documentation from the manufacturer of the lifting line proving that the line being used is the same line that was tested.
- Rated Depth – The certification depth of the HOV.
- Releasable Weight – Weight carried aboard the HOV that can be jettison for increased buoyancy.
- Scientific Personnel – Those persons aboard a vessel solely for the purpose of engaging in scientific research, or for giving or receiving instructions in oceanography. Under the terms of the Oceanographic Research Vessel Act of 1965, these individuals are considered to be neither crew of the vessels nor passengers.
- Submersible – see “Human Occupied Vehicle.”
- Submersible Crew – Person(s) aboard the submersible responsible for its operation.
- Submersible Operations Coordinator – The Submersible Operations Coordinator, is also referred to as the Expedition Leader or Submersible Operations Director. See “Expedition Leader.”
- Submersible Operations Director – The Submersible Operations Director, also referred to as the Expedition Leader or Submersible Operations Coordinator. See “Expedition Leader.”
- Submersible Support Group – Personnel required to operate and maintain the submersible and its systems at sea and personnel ashore assigned to the support of the at sea team. Normally unique from those personnel who operate the support ship or conduct scientific investigations.
- Submersible Support Ship – A ship that through its design, construction, or conversion is capable of and tasked with the transportation, launch, recovery, and support of an HOV.
- Tracking System – A system aboard a submersible support ship that is used to determine the submersible's depth and position during deployment.
- U.S. Navy Inspection and Survey (INSURV) – An inspection and survey protocol performed by the United States Navy for vessels owned and/or operated by agencies of the Navy.

2.2 ACRONYMS

ABS	American Bureau of Shipping
AUV	Autonomous Underwater Vehicle
HBOI/FAU	Harbor Branch Oceanographic Institution/Florida Atlantic University
HOV	Human Occupied Vehicle
HURL	Hawaii Undersea Research Laboratory
INSURV	Inspection and Survey
ISM	International Ship-Safety Management
NAVSEA	Naval Sea Systems Command
NDSF	National Deep Submergence Facility
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OQE	Objective Quality Evidence
OSHA	Occupational Safety and Health Administration
PFD	Personal Flotation Device

ROV	Remotely Operated Vehicle
RVSS	Research Vessel Safety Standards
SMM	Safety Management Manual
UNOLS	University-National Oceanographic Laboratory System
USCG	United States Coast Guard
VHF	Very High Frequency
WHOI	Woods Hole Oceanographic Institution

3. PROCEDURES AND APPLICATIONS

3.0 INTRODUCTION

This document establishes safety standards for the use of Human Occupied Vehicles (HOVs), including the vehicle, the ship, and the handling system. They provide guidance for HOV operations, training of submersible and ship personnel, and suggestions for the scientific crew. These standards are not intended to provide detailed operating procedures for specific HOV systems. They are intended to provide guidance to organizations that develop such procedures.

3.1 STANDARDS

These safety standards provide guidelines for the operation of research HOVs operated or chartered by Members of UNOLS to assure that submergence research at sea is conducted to the highest practicable standards of safety and prudence. Each Member Institution is encouraged to comply with them as applicable to the HOVs under their control. Specific use of these standards shall be set forth under the terms of the user's charter and made to meet the unique characteristics of each vehicle. The operators of other HOVs are invited to make use of them.

3.2 REFERENCE MATERIAL

HOV and support ship operators are responsible for maintaining updated and pertinent reference materials**.**

3.3 CHANGES AND UPDATES

All proposed changes to these standards shall be submitted to UNOLS. Periodically, but not later than every three years, an assigned UNOLS subcommittee will convene to review the safety standards and any proposed changes to ensure that the standards are current and complete. Institutions and agencies will review these standards and any updates to these standards for acceptance and implementation into their respective programs.

4. OPERATIONS

4.0 INTRODUCTION

The purpose of this chapter is to outline the subjects to be included in a Human Occupied Vehicle (HOV) operations plan that will assure adequate safety standards for all HOV operations.

Safe and effective HOV operations normally require the efforts of trained personnel working together in accordance with a documented set of procedures. The maintenance and operations of an HOV approved for use with UNOLS vessels or other federally-owned or chartered vessels must be conducted in accordance with a written operations plan, available for review by the vessel operator in advance of the cruise dates.

4.1 OPERATIONS PLAN

The HOV Operator's written operations plan must include and cover the following subjects:

4.1.1 Organization and Position Descriptions – The written plan must include a description of the operator organization and a description of each position and its associated responsibilities.

4.1.2 General Operational Considerations

- Conditions required for diving
- Operational clearance considerations
- Coast Guard notification and foreign clearances
- Emergency procedure requirements
- Communications information - normal and emergencies including procedures for medical emergencies

4.1.3 Vehicle Information and Performance Data

- General vehicle size, weight, and performance specifications
- Stability information
- Description of life-support system and its capacity
- Depth gauge calibration curves
- Communications capabilities
- Tracking systems
- Surface locating devices
- Ballast system capacities
- Releasable weight documentation
- Emergency lifting devices
- Rescue vehicles

4.1.4 Requirements for Surface Support Vessel Launch and Recovery System

- Hardware
- Personnel
- Qualifications, training, and certifications

4.1.5 Normal Operating Procedures

- HOV General
- Launch and recovery

- Minimum requirements for diving
- Diving procedures
- Surfacing procedures
- Submerged operations and operating limits that address environmental conditions
- Communications
- Life-support systems
- Content of observer briefing

4.1.6 Special Considerations, Procedures and Limitations Applicable to the Intended Cruise – HOV operations sometimes occur in geographic locations or environments that require special considerations. Examples of some of the conditions that require special guidance include:

- Requirements for User-provided Science Equipment
- Operations in the vicinity of high temperature hydrothermal vents and lava flows
- Multi-HOV operations
- HOV / Remotely Operated Vehicle (ROV) operations
- HOV / Autonomous Underwater Vehicle (AUV) operations
- Operations in the vicinity of glass spheres
- Operations at cabled observatory sites

4.1.7 Emergency Operating Procedures

- Fire procedures
- Emergency life-support system
- Emergency battery system
- Atmosphere control casualties
- Loss of contact with surface support
- Entanglement casualty
- Emergency surfacing procedures
- Emergency response of surface personnel

4.1.8 Casualty Procedures and Information for Scientists/Observers - Written emergency procedures should be included in the operations plan to instruct the scientist/observer on how to control and surface the submersible in the event that the pilot is no longer able to do so. The procedures should cover the following topics:

- Power control/conservation
- Communications
- Life support
- Surfacing procedures
- Recovery

4.1.9 Documentation of System Certification

- Certification of HOV
- HOV handling system

4.1.10 Documentation of Pilot Qualifications

4.1.11 Requirements for Maintenance and Change Documentation

- Routine maintenance documentation
- Weight and stability monitoring
- Engineering change approvals and documentation
- Inspection and equipment failure reports

5. SUPPORT SHIP

5.0 INTRODUCTION

The purpose of this chapter is to provide guidelines for the operation of ships that support Human Occupied Vehicles (HOVs) that will assure adequate safety standards for all HOV operations.

The UNOLS Research Vessel Safety Standards (RVSS) provide guidelines and instructions for the operation of oceanographic research vessels owned, operated or chartered by members of UNOLS to assure that research at sea is conducted to the highest practicable standards of safety and due diligence. Vessel operators are reminded that, in addition to the legal responsibilities and liabilities associated with federal laws and regulations and maritime law, safe operation is one of the factors used by federal science sponsors in evaluating the merit of a research platform and its utilization by the science investigators they fund.

Any UNOLS vessel, or any ship chartered for this purpose by a UNOLS member institution, utilized for the deployment of HOVs must meet the UNOLS RVSS. Depending upon its size, ownership, and regulatory regime, the ship may be required to meet American Bureau of Shipping (ABS) standards, U.S. Coast Guard (USCG) Inspection, and U.S. Navy Inspection and Survey (INSURV) – or any combination of these. In addition to these agencies, the National Science Foundation (NSF) supports and directs an inspection program for UNOLS research ships to assure their compliance with the UNOLS RVSS. The National Oceanic and Atmospheric Administration (NOAA) has in place a similar safety inspection regime for NOAA ships.

5.1 ESSENTIAL CAPABILITIES OF THE SUBMERSIBLE SUPPORT SHIP

5.1.1 Two-way communication - The surface support vessel must have the ability to conduct two-way communications with the HOV both on the surface and beneath the surface throughout the design operating envelope of the vehicle in whatever sea state operations are to be conducted. Typically, this communication system will include Very High Frequency (VHF) radio-telephone communications when the HOV is on the surface, and an acoustic underwater telephone system employed when the vehicle is submerged. A procedure for loss of communication must be provided.

5.1.2 Tracking - The support ship must have a means for tracking of the position and depth of the HOV.

5.1.3 Transducers - Transducers for acoustic tracking and communications systems, both on the surface ship and on the submersible, must be mounted so that there are no blocked azimuth angles, and so that the propagation covers maximum horizontal distances and depths expected to be encountered under both normal and emergency operational scenarios.

5.1.4 Personnel Training - Personnel assigned to the operation of the tracking/ communications equipment on the ship must be provided with proper training and technical support (including spare parts). The importance of training cannot be over-emphasized. Please see Chapter 7 of this document.

5.1.5 Depth-Sounding Equipment - The surface support ship must have an adequate suite of depth-sounding equipment capable of determining the precise depth of the water in which the HOV will be operating. Sufficient spares, backup systems, and technical support of these essential components must be provided.

5.1.6 Self-Rescue Capability - Rescue assets and outside assistance for an entrapped or entangled submersible may, depending upon operating area and environmental conditions, be days away. The surface support ship and/or submersible must therefore be equipped with a self-rescue capability. This may consist of a second HOV, a Remotely Operated Vehicle (ROV) system, a releasable personnel sphere, or a passive buoy tag-line captive engagement system. The self-rescue system must be operational throughout the depth range at which the submersible is capable of operating. Realistic drills and exercises or simulating a submersible rescue scenario shall be held at regular intervals, no less than once a year, and the results documented, to assure the integrity of the rescue equipment and to familiarize the personnel on the surface ship and the HOV with its use. These drills/exercises may include tabletop exercises or comprehensive reviews of safety or rescue plans.

5.1.7 Self-Sustaining Capacity - In the event of entrapment, entanglement, or component failure, life support for at least 72 hours should be available in the submersible, i.e., air, water, and food.

5.2 ADDITIONAL DESIRABLE CAPABILITIES

5.2.1 HOV Servicing Space - A vessel supporting a human occupied submersible should offer adequate space for routine servicing and maintenance of the embarked HOV. This may include such elements as a machine shop, an electronics shop, or a dedicated space on board for these functions. Separate storage space for the submersible's spare parts, in a secure location, where they will not be depleted to meet other routine ship maintenance needs should be provided. Since maintenance and battery charging often take place at night, adequate lighting of the work area that can be aimed so as to illuminate the submersible while not blinding the bridge watch-keeping personnel should be provided by the vessel.

5.2.2 Seafloor Mapping System - Equipping the support ship with a multi-beam seafloor sonar mapping system by which an operational area may be examined and mapped before deployment of the HOV is encouraged. These systems provide data of considerable utility to the science investigators but also enhance safety and security by verifying the depth and topography of the seafloor, the presence of wrecks or other entanglement hazards, and assist in localization of the submersible and positioning of a rescue vehicle during an emergency scenario.

5.2.3 Science Laboratories - Laboratories for the use of the science party to sort, preserve, analyze, and experiment with the collections made by the HOV are an implicit requirement for an expedition that employs any undersea platform. A laboratory layout that segregates wet samples from dry equipment is optimal. Details of such laboratories are covered elsewhere in the RVSS and Science Mission Requirements for the various classes of UNOLS vessels <http://www.unols.org/committees/fic/smr/index.html>.

5.2.4 Acoustic Doppler Current Measuring System - Equipping the vessel with an acoustic Doppler current measuring system is recommended. This sonar can help the operators

determine the presence, direction, and velocity of undersea currents before the HOV is launched, and assist the surface vessel in determining environmental factors critical to dynamic positioning (see next item).

5.2.5 Dynamic Positioning Systems – It is desirable that ships assigned to the mission of submersible support should be equipped with dynamic positioning systems. This equipment serves to efficiently keep the surface vessel within a defined position above the submersible's location. Some systems permit automatic tracking of the HOV acoustic transponder, moving the surface ship in concert with the submersible. The bridge personnel can thus better dedicate their attention to monitoring systems and watching out for conflicting surface traffic during lengthy dive operations.

5.3 CHAIN-OF-COMMAND DURING HOV OPERATIONS

As per maritime law and tradition, the Master retains responsibility for and authority over all operations conducted aboard the ship, including the deployment of any off-board vehicles employed by the vessel or its embarked personnel. The Expedition Leader is responsible for and has authority over the HOV and its embarked personnel. The designated HOV pilot commands the HOV and has responsibility for and authority over its operation. The Chief Scientist, as described elsewhere in this document, is in charge of the mission. Unless accomplishment of his/her desires with respect to the expedition plan is unsafe or illegal, the Master and other key individuals responsible for HOV operations should make every attempt to facilitate science needs.

Four persons have ***launch veto*** authority. The Master, the Expedition Leader, the HOV pilot, or the Chief Scientist can make a “no-go” decision (On occasion, the HOV pilot may also fill the role of Expedition Leader). The other members of the mission may not outvote or over-ride such a call. In any case, a decision to proceed with an HOV dive should be a consensus decision of these key leadership personnel but it must be understood that a simple majority cannot over-rule a “hold” or “no go” determination by any one of these key personnel.

Similarly, a decision to terminate a dive early and to recover the HOV may become necessary due to a change in the weather, mechanical issues on the HOV or the support ship, conflicting traffic, or personnel needs. Again, any one of the key leadership personnel identified in the preceding paragraph can order an early termination of the dive. The final say on the actual timing of the surfacing—unless there is a situation requiring the submersible to make an emergency ascent—is routinely deferred to the Master who will take into account actual surface conditions and the position of the ship with respect to the HOV, maneuvering the ship as required for the recovery procedure.

5.4 SUBMERSIBLE SUPPORT SHIP PROCEDURES

Prior to the commencement of HOV launch procedures, the following steps must be taken: (Operators will define step-by-step checklists.)

5.4.1 Weather Assessment - Assessment of weather, sea-state, and visibility forecast for the anticipated end time of the dive and recovery plus long range forecasts for the life support capabilities of the HOV in emergency conditions.

5.4.2 Operating Area Assessment - Assessment of the operating area including currents, bottom depth, and the possible presence of seafloor hazards that create an undue risk of

damage to or ensnarement of the HOV.

5.4.3 Surface Traffic Assessment - Assessment of surface traffic, especially in areas of heavy recreational boating and / or fishing activity.

5.4.4 Establishment of Communication Protocol - Establishment of radio and underwater telephone protocol, selection of frequencies and intervals for communications with the HOV, and announcements on the radio guard channels to warn off other shipping.

5.4.5 Conduct Planning Meetings - Conducting planning meetings, as needed, including the Expedition Leader, the HOV Pilot, the Chief Scientist, and the Scientist(s)/Observer(s) who will be embarking in the HOV, and ship personnel if required.

5.4.6 Surface Support Assignments - Assignment of launch/recovery personnel and the handling system operator. Ensure that all deck personnel are equipped with Personal Flotation Devices (PFDs), hard-hats, and proper footwear, and that common signals are understood by all. Verifying clear two-way communications between the deck, the handling system control location, and the bridge watch-keepers.

5.4.7 Evaluate Dive Conditions - Continuous evaluation of conditions and hazards during the dive.

5.4.8 Establishment of Abort Dive Procedure - Establish an unambiguous decision process for an abort of HOV operations and submersible recovery in the event of an emergency, inclement weather, or other unanticipated event.

5.4.9 Address Unique Operations - The institution's Procedures Manual must address unique operations such as multiple simultaneous HOV operations, simultaneous HOV and ROV or Autonomous Underwater Vehicle (AUV) operations, submersible rescue drills, and coordination with other research vessels present in the immediate area.

5.5 INTERNATIONAL SHIP-SAFETY MANAGEMENT AND SUBMERSIBLE SUPPORT SHIP OPERATIONS

All UNOLS Ocean-Class and Global-Class ships, as well as the R/V *Ka'imikai-O-Kanaloa***,** support ship for the NOAA/HURL submersibles, operate under ongoing safety management systems as per the International Ship-safety Management (ISM) treaty and national implementing laws and regulations. Smaller vessels in the UNOLS fleet are encouraged to comply with ISM to the fullest extent possible.

ISM Procedures for vessels already mandate specific written plans for over-the-side science operations; however these procedures may be fairly generic. Ships conducting launch and recovery of HOVs shall also provide specific written procedures and include them in their reviewed and approved ISM handbooks and other documentation, as required. ISM Procedures for HOV operations will include, at a minimum:

5.5.1 Trained personnel on the support ship required for launch and recovery operations.

5.5.2 Chain-of-Command and designation of lead personnel during operations.

5.5.3 Communications between the deck, the handling system control position, the bridge, and

the HOV.

5.5.4 Weather and operational safety constraints.

5.6 HOV SHIP-MOUNTED HANDLING SYSTEMS

In general terms, a submersible handling system for the launch and recovery of an HOV is a robust, specially designed piece of precision heavy-lift equipment. It is built, operated and maintained to exacting standards so that the delicate and human-occupied submersible can be safely and securely hoisted off the deck, placed into the water and recovered after the dive operation--while under full control during the widest possible window of sea-state conditions.

The handling system:

5.6.1 Ship and submersible system operators must make themselves aware of any regulations, promulgated by the USCG or Occupational Safety and Health Administration (OSHA) or classification societies that may require lifting equipment to be "man rated" or "human rated," and the applicability of such regulations to the anticipated operation and deployment of an HOV.

5.6.2 Must meet and be certified under ABS, Naval Sea Systems Command (NAVSEA) system certification, or another appropriate classification society.

5.6.3 Must have operator qualifications and training established by the HOV operating institution.

Additional information regarding HOV handling systems is described in Chapter 6 of this document.

5.7 TRAINING OF SUBMERSIBLE SUPPORT SHIP PERSONNEL

Submersible support from a surface ship is sufficiently unique as to require specialized training for personnel involved in these operations. This training should include the Master, the bridge watch-keeping officers, the sonar/underwater communications and tracking operators, swimmers (if used), deck personnel, and handling system operators. As required for seagoing personnel under ISM, a syllabus for training shall be established and sign-off documents of training milestones and qualifications shall be maintained (see Chapter 7).

Emergency exercises and drills shall be held to verify the readiness of the rescue and emergency equipment and the personnel tasked with its employment. Pre-dive briefs and post-dive debriefs along with post exercise critiques are useful practices for advising personnel about performance needs and opportunities for improvements. Institutions operating HOVs are encouraged to share experiences through professional organizations, technical journals and publications, and submersible operations sessions at professional meetings.

6. HANDLING SYSTEMS

6.0 INTRODUCTION

The purpose of this chapter is to provide guidelines for Human Occupied Vehicle (HOV) handling systems that will assure adequate safety standards for all HOV operations.

The launch and recovery equipment, whether it consists of an 'A' frame, a crane, or a moveable platform, is an integral component of the surface support vessel and one of three major components that comprise the HOV system: the vehicle, the vessel (support platform), and the handling system. The HOV handling system must meet applicable requirements for human-rated lifting systems and meet the special requirements stated below (6.2). The addition of *ad-hoc* launch, recovery and lift arrangements to a ship-of-opportunity is not an acceptable alternative.

6.1 REFERENCES

The following documents provide the certification and inspection information that relates to HOV handling systems. As these documents may be updated or amended periodically, ship operators must ensure compliance with the latest editions.

6.1.1 **American Bureau of Shipping** (ABS) – Rules for Building and Classing Steel Vessels (2007) – Part 7: Rules for Survey after Construction, Chapter 11, Section 3 - Annual Survey and Sections 4 / 5 Special Periodic Survey

6.1.2 **System Certification Procedures and Criteria Manual for Deep Submergence Systems** – Naval Sea Systems Command (NAVSEA) SS800-AG-MAN-OID / P-9290 Rev. A. Appendix H

6.1.3 **Regulatory Requirements** - Research vessels that have the capability to support HOVs shall meet all regulatory requirements as dictated by International Tonnage (refer to the Research Vessel Safety Standards (RVSS) Chapter 3 Certification, Documentation and Inspection).

6.1.4 **Safety Standards for HOVs, Chapter 5** - Additionally research vessels that will support HOV operations must comply with the standards set out in Chapter 5.

6.2 REQUIREMENTS FOR HANDLING SYSTEMS

6.2.1 The Submersible Support Ship's International Ship-Safety Management (ISM) System must specifically address limitations, operations procedures, periodic tests and inspections, and personnel requirements for utilizing the dedicated HOV launch and recovery handling system.

6.2.2 If the handling system will ever be utilized while the HOV is occupied in the lift/launch/recovery/deck-transfer modes, it must be rated for such service by ABS, NAVSEA, or another appropriate classification society.

6.2.3 The operating institution's Operations Manual should detail the launch and recovery procedures to be followed, consistent with the ISM system under which the HOV support

vessel operates.

6.2.4 All required certificates must be kept current with copies carried aboard the HOV support vessel and copies in the appropriate management offices ashore.

6.3 LIFTING LINE CERTIFICATION

Different handling systems employ various types of lift lines. These lift lines must meet standards (delineated below) for breaking strength.

6.3.1 *Method of Break Testing Synthetic Fiber Ropes* - The break test for synthetic fiber rope shall be in accordance with FED-STD 191, ASTM D4268 or the Cordage Institute Standard Test method for fiber rope.

6.3.2 *Method of Break Testing Wire Ropes* - The Break Test for wire rope shall be FEDSPEC-RR-W-410D, wire rope and strand or an approved industrial standard.

6.3.3 The Objective Quality Evidence (OQE) is the documentation from the manufacturer of the lifting line proving that the line being used is the same line that was tested. The OQE must be maintained with the other HOV handling system certifications to relate the rope in use to the required breaking strength test.

7. TRAINING PROCEDURES FOR SUPPORT CREW

7.0 INTRODUCTION

The purpose of this chapter is to outline general procedures for training Human Occupied Vehicle (HOV) personnel so as to assure adequate safety standards for all HOV operations.

The American Bureau of Shipping (ABS), which regulates design, construction, and operation of HOVs, recognizes that all HOV operations are different. Submersible types, handling systems, support vessels, and crew requirements vary from operation to operation. In the ABS Manual "Rules for Building and Classing Underwater Vehicle Systems," the section on personnel and training states that such issues as training fall under the purview of local jurisdiction and are specifically not addressed by ABS, and that owners and operators of commercial and non-commercial underwater units are ultimately responsible for, and are to assure themselves of, the competence of those performing activities related to the unit.

Limitations in the number of HOV operating and maintenance personnel can require a high degree of cross-training of HOV and ship crew to assure a reliable backup capability.

7.1 TRAINING AND OPERATIONS MANUALS

HOV operations must have established and documented training and operations manuals (see Chapter 4) that outline crew training, operations procedures, emergency procedures and chain-of-command responsibilities.

The Operations Manual should also outline basic qualifications for HOV crew, including position titles and requirements to meet the demands of the defined positions. This should also include any mental and physical requirements of the defined jobs.

7.2 TRAINING SYLLABUS

An HOV operation must have an established and documented syllabus for training that will familiarize HOV crew and pilot candidates with each phase of their HOV operation. This syllabus should include training on principles of submersible design and construction, operational procedures, life support, emergency systems, buoyancy, trim/ballast systems, power and electrical systems, hydraulic and pneumatic systems, propulsion systems, communications, and navigation. The requirements for maintaining certification/classification should be included.

7.3 PROFICIENCY OF THE HOV CREW

HOV operators must have in place a procedure to maintain HOV crew proficiency. This procedure may be in the form of refresher training for individuals or test and trial operations involving the entire HOV operations team. There must be documentation of refresher training operations.

7.4 TRAINING PROCEDURES

Training procedures should include a requirement that HOV crew candidates observe and participate in all phases of their specific HOV programs. Training should include vehicle service

and maintenance procedures, pre- and post-dive procedures, launch and recovery procedures, topside dive support operations such as navigation, communications and tracking, shipboard support facilities, dive mission requirements, and chain-of-command responsibilities. HOV personnel should be involved with vehicle refit procedures whenever they occur.

A pilot in training must be required to participate in operational dives and accumulate a minimum number of hours and operational dives before being considered eligible to qualify as a pilot. The specific training requirements of an operator should be detailed in their Training Guidelines or by other operational documents.

A pilot-in-training must be able to demonstrate knowledge of the submersible systems and operations to the satisfaction of the operator's Chief Pilot or training supervisor and, if required, certifying agency.

7.5 HOV TRAINING DOCUMENTATION

HOV operators must have documentation for all training and qualifications of HOV pilots, pilot candidates, and associated HOV and ship's crew throughout the progression of training and experience. A pilot or operational organization must establish and maintain a record that documents dive time and submersible dive experience.

HOV operators must demonstrate a minimum level of documented technical training and qualification in the areas listed in sections 7.2, 7.4 and 7.6.

Assigned duties will vary from operator to operator as well as the size and technical makeup of the crew. Any cross training with crew of the support ship should be documented in the ship's Safety Management Manual (SMM).

7.6 SUBMERSIBLE AND SHIPBOARD EMERGENCY PROCEDURES

All HOV operators must conduct and document periodic emergency training exercises. These exercises must test the abilities of the HOV crew and pilots to deal with submersible and shipboard emergencies including fire, flooding, leaking gas into the command sphere, loss of power, loss of key systems such as life support, hydraulics, propulsion, ballast and trim, underwater communications and surface communications, loss of tracking by the support vessel, support vessel equipment failures such as propulsion, submersible crew sickness or injury, entanglement, and emergency surface recovery or evacuation procedures.

7.7 SUPPORT SHIP PERSONNEL

It is assumed that the support vessel is one that normally carries the HOV system and that ship and HOV personnel are familiar with operational scenarios. In the case where a vessel of opportunity is used, it is especially vital that ship and HOV operations personnel have a clear understanding of what is required for safe and effective HOV/ship operations.

A documented operations plan should be prepared that clearly outlines HOV operations procedures, chain-of-command responsibilities for ship and HOV crew, HOV emergency procedures, emergency response contact information, and dive operations schedules.

Test and trial operations should be conducted to familiarize HOV and support personnel on the vessel of opportunity with operations procedures.

8. Science User Safety Guidelines

8.0 INTRODUCTION

The purpose of this chapter is to provide guidelines for scientists who use Human Occupied Vehicles (HOVs) so as to assure adequate safety standards for all HOV operations.

Scientists and other observers who dive in HOVs must be given enough information to assess any risks involved, to prepare adequately for dives, to permit safe participation in dives, and to assist or relieve the pilot in the event of an emergency. Effective communication with the science party must therefore begin well before the cruise and continue during the period of HOV operations.

Specifically, the HOV operator must provide written information on HOV safety procedures and risks prior to the cruise and must brief the scientists in the submersible before diving. During this briefing, the pilot or trainer will assess the suitability of the scientist for diving, provide necessary training, and document the briefing in writing stating clearly that the scientist has met the minimum criteria for diving or reason why they have not. The Chief Scientist is encouraged to prepare a complete operations plan and assure that all members of the scientific party are familiar with it.

8.1 WRITTEN INFORMATION FOR THE SCIENCE PARTY

Each HOV operator must provide written or on-line briefing materials for scientists to review prior to the cruise and these materials should also be conveniently available in common areas of the ship. Examples of such documents include the *Alvin* User Manual <http://www.whoi.edu/page.do?pid=10676> and the HURL Science Users Guide <http://www.soest.hawaii.edu/HURL/HURL_Science_Users_Guide_rev6f.pdf>.

This information should include advice or policies on suitable clothing and other items that should be brought on a dive, information on any risks or health concerns associated with HOV work, and any safety related policies on science equipment that might be deployed on the sub or carried in the sphere.

8.2 PRE-DIVE SCIENTIST BRIEFING

All scientists and other observers must be briefed on safety-related issues before diving. Each HOV operator will have a written document with a checklist that outlines the content of this briefing and includes a signature line on which the scientist or observer certifies in writing that s/he has received the briefing. The briefing shall include instructions on fire safety, maintenance of breathing atmosphere, and sufficient instruction on submersible operation to allow a scientist to communicate with the surface and bring the HOV to the surface in the event that a pilot becomes incapacitated or otherwise unable to function.

At least a portion of the briefing should take place in the submersible either at the beginning of a cruise or immediately prior to a dive. During this briefing, the pilot should evaluate the general emotional and physical state of the scientist, assuring that s/he appears suitable (e.g., with respect to claustrophobia, flexibility, general health, etc.) to dive and should specifically ask whether there are any health conditions or current medications that the HOV pilot should know about. The briefing is also a final opportunity to address any questions or concerns the scientist

might have about the dive procedures and risks.

Each scientist, irrespective of prior experience, must receive a complete safety briefing prior to diving on each cruise. The HOV operator will maintain written documentation showing when each briefing was done.