SS800-AG-MAN-010/P-9290

REVISION A

SYSTEM CERTIFICATION PROCEDURES AND CRITERIA MANUAL FOR DEEP SUBMERGENCE SYSTEMS

THIS DOCUMENT SUPERSEDES: NAVSEA P-9290

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DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
2531 JEFFERSON DAVIS HWY
ARLINGTON VA 22242-5160

IN REPLY REFER TO

9077
Ser 92Q4/237
03 Nov 98

From: Commander, Naval Sea Systems Command

Subj: PROMULGATION OF SYSTEM CERTIFICATION PROCEDURES AND CRITERIA MANUAL FOR DEEP SUBMERGENCE SYSTEMS, NAVSEA SS800-AG-MAN-010/P-9290, REVISION A

Encl: (1) SYSTEM CERTIFICATION PROCEDURES AND CRITERIA MANUAL FOR DEEP SUBMERGENCE SYSTEMS, NAVSEA SS800-AG-MAN-010/P-9290, REVISION A
(2) Manual Receipt Verification Form
(3) Summary of Changes Incorporated in Revision A

1. **Purpose.** To promulgate the System Certification Procedures and Criteria Manual for Deep Submergence Systems, Revision A. The revision was developed to provide program changes, technical clarification and update the guidelines for the design, construction, modifications and refinements in the certification process for Deep Submergence Systems (DSS).

2. **Implementation.** This revision supersedes and replaces the current System Certification Procedures and Criteria Manual for Deep Submergence Systems, NAVSEA SS800-AG-MAN-010/P-9290. The requirements of enclosure (1) do not constitute authority to make changes in any government contract or written agreement, to expend funds or change any schedule from those stated in government contracts or agreements. For contracts or agreements in effect prior to the date of this letter, the requirements and specifications referenced will remain in effect for the duration of the contract unless the contract or agreement is specifically modified to include the changes implemented by enclosure (1). Recognizing the substantial investment in existing DSS assets and their logistics base, it is the objective of the implementation policy to enable the use of existing acceptable DSS hardware, software, and their associated objective quality evidence (OQE); enable the continued use of existing approved DSS system specific documentation (e.g. drawings, manuals, maintenance procedures, etc.) without requiring immediate revision only to explicitly address or reference enclosure (1); and, provide the DSS program managers control over the implementation process necessary to manage the impact on existing DSS programs. Implementation policy for enclosure (1) is as follows:

a. All DSS certifications in effect on the date of this letter will remain in effect, subject to the requirements of the Letter of Certification. Existing DSS programs, which are in full compliance with the technical requirements of superceded versions of P-9290, shall be considered compliant with the technical requirements of enclosure (1). All development work on new DSSs, which has already been accomplished in full compliance with the technical requirements of superceded versions of P-9290, shall be considered compliant with the technical requirements of enclosure (1).

b. The DSS Program Managers are responsible for implementing enclosure (1). The schedule for implementing enclosure (1) for DSS certification shall be determined and invoked by the DSS Program Managers. The following is provided as a framework for enclosure (1) implementation:

(1) The processes for administering the DSS Safety Certification program (e.g. review, approval, concurrence, change authorization, DFS processing, audits, surveys, memoranda of understanding, etc.) detailed in enclosure (1) shall be implemented as of the date of this letter.

(2) Operational Units will be operated and maintained by the User Activity in accordance with the requirements of the Letter of Certification. By February 28, 1999, the User Activity shall report to the program manager, the technical requirements from superceded versions of P-9290 (with supporting rationale) which must be retained; and, shall propose a schedule for implementing all other requirements of enclosure (1). Otherwise, all requirements of enclosure (1) shall be effective on February 28, 1999 regardless of the version of P-9290 identified in the Letter of Certification, subject to the limitations stated in this letter.

(3) The requirements of this manual shall be invoked, subject to limitations imposed by contracts existing prior to the date of this letter, by the Sustaining Activity for all SOC work performed including Technical Availabilities (TAVs), Restricted Availabilities (RAVs), and organizational maintenance; and, will be invoked for current construction contracts, overhaul contracts, modernization or conversion, in whole or in part, at the discretion of the Program Manager.

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c. The requirements of enclosure (1) are invoked for all new DSS related acquisitions with effective dates of specification on or after the date of this letter.

3. **ACTION**.

a. Complete enclosure (2) and return it to NAVSEA 92Q.

b. Insert this promulgation letter in the front of each copy of enclosure (1) immediately following the List of Effective Pages.

c. Enclosure (3) is provided for information.

J. P. DAVIS
DEPUTY COMMANDER
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SUMMARY OF CHANGES

NAVSEA SS800-AG-MAN-010/P-9290, REVISION A

1. This manual revision to update the current P-9290, issued in December 1990, was completed in two phases. Phase I consisted of addressing 160 manual change requests that accumulated since the manual was issued. Ten priority items to be included in the revision were established by NAVSEA 92Q and PMS395 prior to the revision. The PMS395/SEA 92Q selected items and the accumulated changes were entered in the manual. The manual was provided to NAVSEA codes and field activities for review and comment after the initial changes were incorporated.

Phase II of this revision was the resolution of over 1000 comments and recommendation that were received as a result of the Phase I review. Review reading sessions were conducted to evaluate and resolve the change recommendations. Change issues considered programmatic in nature, resulting in a significant requirement revision were provided to the Program Managers for review and comment. Changes that resulted in the complete revision of an appendix such as, The General Guidelines for Control of Atmospheric Contaminants in Manned DSS - Appendix F, were submitted to the Cognizant Technical Codes, the Medical Community and selected User Activities for review and comment. All comments resulting from the Phase I review were finalized during additional review reading sessions.

a. The manual revision includes the necessary changes to support OPNAV's FY98 - FY03 RESTRUCTURED DEEP SUBMERGENCE SYSTEMS PROGRAM (DSSP) for:

- Extending the length of certification and periodicity of maintenance.
- Acceptance of commercial standards (UL) for electrical/electronic equipment.
- Review and revise existing requirements for material toxicity testing. Current requirements to test for a host of contaminants at minuscule concentrations are unnecessarily burdensome in both time and cost.
- Review and revise personnel exposure limits to toxic substances. Current requirements are based on long-term exposures and do not take into consideration the actual risks from exposures of less than 24 hours.
- Eliminate required documentation for non-pressure boundary components.

b. The following items provide a summary of the major change areas that PMS395 and SEA 92Q selected to be addressed within this revision;

- Modify material control requirements, allow use of NDI & commercial and industrial.

- Add requirements for Access to and Operation of Vital Equipment.
- Update SCA authorization for wet testing of one atmosphere DSS.
- Strengthen requirements for sustaining certification of existing systems.
- Revise guidance for establishing material off gassing and flammability acceptance.
- Develop implodable standoff curve extensions to address deeper depths and larger volumes.
- Clarify requirements when system safety analyses need be conducted and level of detail required to address installation, control and certification of SHIPALTs, TEMPMODs.
- Revise design guidance for handling systems.
  - -Allow PM to elect to use ABS rules and certification.
- Update the example Certification Survey Plan to reflect current practices and include;
  - -Sea Trial Agenda.
  - -SOC notebook.
- Address process for PMS and REC work.
- Establish specific requirements and conditions for reinstatement of certification.

2. Resolution of these issues resulted in overall structure changes within some chapters and appendices and the relocation and/or consolidation of like requirements. Consolidation of the sequence of events and interrelated certification actions to support operational demonstration and trials from Chapter 4 and Chapter 5 to Chapter 3 was accomplished, which allowed deleting of repetitive requirements. The DSS NAVSEA Sustaining Survey Plan (short form) was revised to reflect current practices and moved to Chapter 4 from Chapter 5. Throughout the manual terminology and titles were revised to reflect current practices such as, Applicant/Program Manager to Program Manager, replaced Deep Submergence Systems with DSS in most parenthetical uses. Specific emphasis was placed on identifying items requiring Program Manager and SCA approval or concurrence, as well as, Clarifying when the Cognizant Technical Authority approval and/or concurrence is required. Certification documentation and responsibilities throughout the manual were consolidated to eliminate redundancy and provide consistency. In several instances specific specifications (Mil-Stds and Commercial Standards) and reference documents replaced procedures and directions to develop procedures. Existing references were updated to replace superseded and canceled documents and the bibliography of reference documents was relocated from Appendix L to New Appendix M to accommodate adding the guidelines for Access To and Operation of Vital Equipment. To assist users, an Acronym Listing and the Index of Terms were developed and included in this revision.

3. The following items provide specific changes that were incorporated:

CHAPTER 1: GENERAL INFORMATION

- Added Background section to provide the DSS Program history of evolution, manual development and lessons learned to emphases the program importance.
- Added the definition of Deep Submergence Systems, personnel and Certification to reflect the current scope of systems addressed by the manual.
- Clarified and expanded the definition of acceptable OQE and addressed the related specific conditions for telecomm and e:mail.
- Added various definitions such as Cognizant Technical Authority, Functional Audit and related Tech Assist.
- Addressed Documentation Hierarchy as related to the SUBSAFE interface.

CHAPTER 2: THE SYSTEM CERTIFICATION PROCESS

- Provided clarification to the System Certification Process and when submissions are required.
- Included OOC in the certification process.
- Clarified the areas to be addressed in the System Safety Plan elements and related analysis definition.
- Revised Figure 2-2, Sustaining/Reinstatement of Certification Process flow chart to reflect current requirements and practices.
- Revised the Scope of Certification (SOC) items clarify areas of concern and thus establish more specific parameters for establishing the SOC.
- Formalized the conditions when a MOU is required to cover certification responsibilities other than principal participants and Sustaining Activities.
- Clarified the Certification Survey Plan approval, management and submission and subsequent survey responsibilities.
- Added new section for DSS SOC Departure From Specifications; definitions, processing, administrative control and record responsibilities.
- Defined and/or clarified sustaining certification survey, operational demonstration, reinstatement of certification, sustaining certification guidelines and responsibilities.
- Defined the Letter Of Certification use and content.
- Clarified Major Modifications identification and defined Temporary Modifications (Temp Mods).
- Added process for manual change consisting of Change Submittal, Change Status and Manual Distribution (Manual Change request form added in front of manual).

CHAPTER 3: REQUIREMENTS FOR CERTIFICATION

- This chapter revision focused on providing a more comprehensive listing of the OQE and identifying the specific documentation to satisfy certification requirements.
- Clarified the Design, Configuration Management and documentation responsibilities.
- Design Parameters - Specific rather than General;
  -Added Design Parameters for weight changes, humidity, electrical protection, results of System Safety Analysis vice anticipated hazards.
  -Operational sea state and Lifting and weight handling requirements,
  -Design Calculations - Structural, Piping, electrical.
  -Revised old (general) Design Calculations to identify specific and separate required design data for each area: structural, piping/mechanical and electrical systems
  -Stress Analysis -more specific requirements.
- Drawings - Top Level Approval rather than all
  -Invoked drawing SOC marking requirement - Stamp SOC
  -Specified Post maintenance availability, overhaul and modification delivery and update responsibilities for drawings.
- Drawing Index - Identifies Top Level drawings that require PM and SCA review -lower tier will be verified during Survey.
- Clarified Operability And Maintainability Requirements to be more understandable.
- Toxicity And Flammability List - specifies what is required on list - no longer requires NAVSEA approval.
- DSS drawing index, drawing and diagram requirements and SOC certification attributes were revised provide better control of the review and approval process.
- Combined Operability and maintainability procedural requirements and related analysis to eliminate redundancy.
- Clarified toxic and flammable materials list, testing and OQE requirements.
- Modified Material Control Requirements to improve usability and allow the use of NDI and commercial/industrial materials.
- Complete revision of the material control divisions A, B, and C marking and related inspections and installation controls.
- Added the direction required for control and transfer of certified material and components from DSS/operating ship or deactivation's to other activities and DSSs.
- Revised the cleaning and OQE requirements for breathing gas systems to reflect current practices.
- Revised welding and brazing procedure from NAVSEA approved only to Defense agency approved as acceptable.
- Revised cleaning procedures from "approved" to NAVSEA approved if differs from requirements of the Mil-Stds, more

detail on what goes in cleaning procedure - clarification on record requirements.

- Added the Access to vital equipment shipcheck test requirement as defined in the guidelines of new Appendix L.
- Clarified that SCA or representative participates in test dive, made applicable to reinstatement of certification.
- The criteria and requirements are provided to allow limited wet testing to achieve certification or reinstatement of certification.
- Revised the MRC notes for SOC maintenance cards and allowed the PM the discretion to select alternate wording for existing DSS programs:
  - -SOC-REC remains as existing practice.
  - -Provided the guidelines and criteria that must be met to allow SOC-NRR.

CHAPTER 4: ON-SITE CERTIFICATION SURVEY

- Moved all survey requirements to this Chapter, Sustaining Certification Survey Periodicity and the reinstatement of Certification Survey with the interim actions and criteria were provided.
- Incorporated criteria and the completion status reporting form to identify the work status to support scheduling SCA Survey.
- Moved Figure 4-2 DSS NAVSEA SUSTAINING SURVEY PLAN from Chapter 5 and revised survey scope to reflect current practices, formalize coverage and accountability to reflect the OQE required to support extending survey periodicity.
- Clarified the internal survey status submission requirements to reflect current practices.
- Revised the Survey card management/reporting and deleted all examples of survey card findings as "no value added".

CHAPTER 5: SUSTAINING CERTIFICATION

- Deleted redundant Sustaining Certification policy and responsibility requirements from the Chapter, these items are covered in previous Chapters.
- Incorporated section to address and control the installation and use of Temporary Modifications (Temp Mods).

APPENDIX A: CATEGORIZATION OF SOC MATERIALS AND COMPONENTS

- Provided numerous clarifications to the Appendix in response to CTA and User comments.
- Replaced canceled Mil-Spec's and Mil-Std's with ASTM Specifications.
- Updated all Specifications, added additional approved CO_2 absorbents.
- Addressed viewing windows other than PVHO-1 materials as being Category 3 materials.

- Delete Pressure Hull/Vessel Nonferrous materials tables of acceptable Category 1 materials as the materials and applications of those material are no longer in use.
- Added the alternative first article testing in lieu of intentional defect testing for structural materials.

APPENDIX B: DESIGN FACTORS FOR DEEP SUBMERGENCE SYSTEMS

- Significant changes throughout the various design sections of this appendix to resolve user comments, clarify requirements, address known problems related to design verification and testing.
- Added section to address design strength parameters of externally loaded pressure hulls/vessels, hard structures and additional section for design strength parameters of internally loaded pressure hulls/vessels, hard structures requirements.
- Revised the verification of calculated collapse pressure and the verification of calculated design operating pressure sections and the related testing procedures/test instrumentation subsections to resolve user comments and provide consistency with other related changes.
- Revised the Stress Analysis to provide more specific requirements and clarity.
- Added testing direction for miscellaneous pressure vessels hard structures.
- Revised design criteria for hull penetrators and electrical penetrators to address safety concerns.
- Updated the viewport and seals (sealing material) sections for clarity and to reflect current practices.
- Hatches/closures section was revised to add demonstrated factor of safety for category 1 and 2 materials.
- added section regarding material selection to address and provide direction for the subsections.
- Updated threaded fastener criteria.
- Deleted outdated and incomplete, Table B-1, Color Code and Designations for Piping Systems and inserted applicable reference document.
- Added section Special Considerations for Oxygen Systems to provide clarity and consolidate oxygen system design guidance.
- Added reference criteria for DSS battery design and specification development.
- Added testing criteria for testing of outboard wiring cables.
- Clarified section for communications systems design requirements and sound level limits.
- Complete re-write of the Life Support System section to eliminate redundancy and consolidate random design criteria in one location and augment the revision of Appendix F.

APPENDIX C: TESTING PARAMETERS FOR PERMANENTLY OR TEMPORARILY MOUNTED EXTERNAL IMPLODABLE AND EXPLODABLE ITEMS

- Complete Revision of the Appendix.
- Clarified design requirements for implodables:
  - -Each request must be evaluated.
  - -States not applicable to items recovered off sea floor.
  - -Implements analysis Program to be done by N/S.
  - -Critical Implodable test requirements remove some.
  - -Stand off curves/formula - limited application – deleted.
  - -Clarifies testing requirements for repairs to implodables.
  - -Explodable testing - Added for items that are not considered hard structure and which are internally pressurized.

APPENDIX D: TESTING PARAMETERS FOR EXPLODABLE ITEMS DUE TO COMPRESSION

- Provides specific test guidance and acceptance criteria,
- Addresses porous and vented component criteria to clarify requirements.
- Deleted the sampling Table D-1, as written the requirement is 100% testing of potentially explodable items or the PM may provide justification and request relief from the requirement on a case basis.
- Revised testing criteria and added section to address porous or vented components.

APPENDIX E: DSS BREATHING GAS AND ATMOSPHERIC REQUIREMENTS

- Replaced Figure E-1 Relationship of Respiratory Minute Volume and Oxygen Consumption Rate to Type and Level of Exertion with new Figure E-1 Relation of Respiratory Minute Volume and Oxygen Consumption Rate to Type and Level of Exertion, this new Figure from the Navy Diving Manual contains additional information.
- Added new Table E-1 Effects of various O2 Partial Pressure for additional information.
- Reformatted Figures E.2, E.3 and E.4 to make the forms compatible with electronic transfer.

APPENDIX F: GENERAL GUIDELINES FOR CONTROL OF ATMOSPHERIC CONTAMINANTS IN MANNED DSS

- The Appendix was completely revised, restructured and updated to reflect the program expansion and changes in atmospheric control. Many of the requirements and discussions contained in other parts of the manual have been deleted from those locations and relocated and incorporated in this Appendix.
  - -PM has responsibility to establish controls.
- Added 5 atmospheric/breathing gas and contaminants related tables for identification of atmospheric contaminants and levels.
- Developed new Flammability Test section and added acceptance criteria table.

APPENDIX G: GENERAL GUIDELINES FOR CLEANING BREATHING GAS SYSTEMS

- Revision of the Appendix included deletion of the canceled Mil-Stds and Specifications, additions of concerns, Commercial Stds and revised cleanliness standards and process instructions.
- Changed from general guidelines for developing procedures and criteria to guidelines to address the issues associated with and cleaning of life support systems and invoked specific guidance provided by approved procedures.
- Provides approved cleaning agents – IAW Mil-Std-1330 and Mil-Std-1622.
- Addresses agents to stay away from and compounds which can generate deadly gases in some CO_2 removal systems.
- Cleaning processes:
  - -Addresses commercial specs to be wary of.
  - -Addresses approval requirements for use of commercial specifications.
  - -Deletes the old processes.
- Maintaining Cleanliness:
  - -Use of 10 Micron filter upstream of charging connection.
  - -Preventing entry of foreign material.
- Deleted commonly used definitions and discussion of cleaning agents, covered in appendix F.
- Relocation of several sections to Appendix F.

APPENDIX H: DESIGN GUIDELINES FOR DSS HANDLING SYSTEMS

- Extensive revision of the Appendix to provide certification parameters and design, fabrication and testing criteria.
- Allows Program Manager to elect to use ABS commercial design criteria and certification.
- Definitions were added and changed to better cover current handling program scope.
- Added system design environmental considerations for sea state, air and water temperatures, wind velocity, precipitation, ocean currents and corrosion.
- Revised existing tables and added 3 new tables to address maintenance.
- Complete revision of the DSS support Ship Annual survey Plan with added criteria:
  - -Tables for wire rope replacement and synthetic line inspection (used extensively).
- Replaced Figure H-1 DSS Support Ship Annual Survey Plan with new plan and format to improve accountability and ease of use.

APPENDIX I: RE-ENTRY CONTROL PROCEDURES

- Requires use of the manual REC procedures or a control system and procedures that fulfill requirements contained in Appendix I.

- Made consistent with SUBSAFE to identify excepted requirements.
- Identified that Fleet, 0010 REC requirements are acceptable so long as the RECs Identified as SOC.
- REC exemptions of what work can be approved.
- Added REC exceptions section to make P-9290 compatible with other programs and practices for routine maintenance and operations.
- Deleted associated REC provision, changed some of the activity designations for responsible personnel.

APPENDIX J: DSS PIPE AND PIPING COMPONENTS PRESSURE TESTING REQUIREMENTS

- Significant changes to the appendix to reflect current practices and delete requirements that covered in other documents and may contain conflicting direction.
- Test pressure time requirements made consistent with other test requirements.
- Clarified test acceptance OQE.

APPENDIX K: CERTIFICATION SURVEY PLAN

- The sample/example plan represents the CSP being used on the DSVs and reflects the requirements that have been incorporated to develop a satisfactory CSP, from the previous CSP example for surveys subsequent to the initial survey.
- Added the CSP example for DSS Handling Systems. Provided items and OQE that must be addressed for Initial Certification of a DSS Handling System.
- Added clarification for change update and approval – removed the requirement to get CSP approved each time a survey is done:
  - -Requires update of the CSP for each survey.
  - -Requires activities doing work to update CSP.
- Revised the standard format of the CSP to an electronic compatible format.

APPENDIX L: ACCESS TO AND OPERATION OF VITAL EQUIPMENT

- Developed and added requirements and guidelines for Access To and Operation of Vital Equipment and sample figures to reflect current practices.

APPENDIX M: BIBLIOGRAPHY

- Complete update of the reference documents to reflect current status and usage.

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LIST OF ABBREVIATIONS AND ACRONYMS

3-M	Maintenance and Material Management
ABS	American Bureau of Shipping
ACGIH	American Conference of Governmental Industrial Hygienists
ANU	Approved for Navy Use
ASW	Auxiliary Seawater
ATA	Atmospheres, Absolute
ATM	Atmospheres
BTPS	Body Temperature; Ambient Barometric Pressure; Saturated with Water Vapor
BUSHIPs	Bureau of Ships
CAS	Chemical Abstracts Service
CASREP	Casualty Report
CFM	Cubic Feet per Minute
CNM	Chief of Naval Material
CO_2	Carbon Dioxide
COC	Certificate of Compliance
COT	Certificate of Test
COTS	Commercial-Off-The-Shelf
CSMP	Current Ship's Maintenance Program
CSP	Certification Survey Plan
dB	Decibel
DC	Direct Current
DDS	Dry Deck Shelter
DFS	Departure From Specification
DSRV	Deep Submergence Rescue Vehicle
DSS	Deep Submergence System
DSSP	Deep Submergence Systems Program
DSSRG	Deep Submergence Systems Review Group
DSV	Deep Submergence Vehicle
E-MAIL	Electronic Mail
EDL	Equipment Deficiency List
EHP	Electrical Hull Penetrator
EIPS	Extra Improved Plow Steel
ENG	Engineering Officer
ESL	Equipment Status List
FAT	Factory Acceptance Test
FC	Full Compliance
FEMA	Failure Effects and Mode Analysis
FFF	Form, Fit, and Function
FID	Flame Ionization Detector
FWP	Formal Work Procedure
GC	Gas Chromatograph

HP	High Pressure
HPU	Hydraulic Power Unit
IMA	Intermediate Maintenance Activity
IPS	Improved Plow Steel
IR	Insulation Resistance
JCN	Job Control Number
JO	Job Order
JSN	Job Sequence Number
LSS	Life Support System
MBT	Main Ballast Tank
MCD	Material Control Division
MCR	Manual Change Request
MIC	Material Identification and Control
MOU	Memorandum of Understanding
MRC	Maintenance Requirement Card
MS	Mass Spectrometer
MT	Magnetic Particle Inspection
NASA	National Aeronautics and Space Administration
NAVMAT	Naval Material Command
NAVSEA	Naval Sea Systems Command
NDI	Nondevelopmental Item
NDT	Nondestructive Testing
Ni-Al-Brz	Nickel-Aluminum-Bronze
Ni-Cu	Nickel-Copper
Ni-Cu-Al	Nickel-Copper-Aluminum
NIOSH	National Institute for Occupational Safety and Health
NSN	National Stock Number
O&SHA	Operating and Support Hazard Analysis
OAS	Obstacle Avoidance System
OIC	Officer in Charge
Op/Insp	Operating and Emergency Procedure Verification
OPNAV	Office of the Chief of Naval Operations
OPs/EPs	Operating and Emergency Procedures
OQE	Objective Quality Evidence
OSHA	Occupational Safety and Health Administration
PID	Photo-Ionization Detector
PMS	Planned Maintenance System
POA&M	Plan of Action and Milestones
PPB	Parts per Billion
PPM	Parts per Million
PSF	Pounds per Square Foot
PSIA	Pounds per Square Inch, Absolute
PSIG	Pounds per Square Inch ,Guage
PSOB	Pre-Survey Outline Booklet
PT	Liquid Penetrant Inspection

PTC	Personnel Transfer Capsule
QA	Quality Assurance
RAV	Restricted Availability
REC	Re-entry Control
RMV	Respiratory Minute Volume
RQ	Respiratory Quotient
RT	Radiographic Inspection
RV	Research Vehicle
S & T	Strength and Tightness
SAR	Safety Analysis Report
SCA	System Certification Authority
SCFH	Standard Cubic Feet per Hour
SDI	Ship's Drawing Index
SECNAV	Secretary of the Navy
SEV	Surface Equivalent Value
SHIPALT	Ship Alteration
SLPM	Standard Liters per Minute
S_m	Allowable Operating Stress
SOC	Scope of Certification
SOC-NRR	SOC - No REC Required
SOC-REC	SOC - REC Required
SOT	System Operational Test
SPL	Sound Pressure Level
STDP	Standard Temperature and Pressure, Dry Gas
STP	Standard Temperature and Pressure
SUBSAFE	Submarine Safety
TAV	Technical Availability
TECH ASSIST	Technical Assistance Review
TELCON	Telephone Conversation
Temp Mod	Temporary Modification
TIPE	Transponder Interrogator Pinger Echo-Sounder
TL	Team Leader
TLV	Threshhold Limit Value
TR	Time Required
TV	Television
UL	Underwriters Laboratories
UQC	Underwater Telephone
URO	Unrestricted Operations
USN	United States Navy
USS	United States Ship
UT	Ultrasonic Inspection
UV	Ultraviolet Light
VB	Variable Ballast
VM	Verification of Material
VT	Visual Testing

P-9290 MANUAL CHANGE REQUEST (MCR) FORM

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OTHER MANUAL SECTIONS AFFECTED:	POINT OF CONTACT: COMMERCIAL: DSN:

***RECOMMENDED CHANGE*:**

***RATIONALE/JUSTIFICATION*:**

RELATED DOCUMENTATION: (This includes any references or documents which may be affected by recommended change).

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Chapter 1
General Information

1.1 Introduction

a. This manual establishes the material and procedural requirements for Deep Submergence System (DSS) certification of manned noncombatant submersible, submarine oriented DSSs including diving systems and the man rated portions of their handling systems. The objective of the certification process is to verify that a DSS provides acceptable levels of occupant safety throughout the specified operating range of the system when approved operating and maintenance procedures are followed. It is not intended to restrict the development or use of new ideas, systems, hardware or equipment.

b. Certification to this manual is a prerequisite for use of any DSS by both Department of the Navy military and civilian personnel, and for use of a Department of the Navy owned DSS by any personnel.

c. The intent of the certification process is to provide maximum reasonable assurance that a material or procedural failure that imperils the operators or occupants will not occur. Certification ensures that conditions adversely affecting the safety of DSS personnel are mitigated and verifies that no recognizable unsafe conditions exist. The certification process also establishes maximum reasonable assurance that DSS personnel may be recovered without injury if there is an accident.

d. The philosophy of certification is therefore only to consider recovery of DSS personnel without injury based on a single failure scenario, except for catastrophic failure of the primary pressure hull boundary.

1.2 Background

1.2.1 History

a. The Deep Submergence Systems Program (DSSP) resulted from the Deep Submergence Systems Review Group (DSSRG) which was formed after the loss of the USS THRESHER (SSN 593), with all hands in April 1963. The Secretary of the Navy (SECNAV) directed the DSSRG to examine the Navy's plans for the development and procurement of components and systems related to location, identification, rescue from, and recovery of deep submerged large bodies from the ocean floor and to recommend a program that would result in optimizing the future effectiveness of such components and systems. In February 1964, the DSSRG recommended establishment of a program to provide management and special attention to the improvement of the Navy's capabilities in such areas. On 15 May 1964, management of DSSP was assigned by the SECNAV to the Director, Special Projects. By 1966, the need for DSSP to become

a separate project became apparent. The Chief of Naval Material (CNM) established and chartered DSSP as a CNM designated Program (PM11) in February 1966.

b. The Navy started certifying submersibles using a technical Letter of Requirements in the 1964-65 time frame. The submersibles ALVIN (Navy owned) and DEEPSTAR 4000 (Navy leased) were the first to be certified to the technical Letter of Requirements.

c. The Chief of Naval Operations, pursuant to the authority assigned by SECNAV, issued OPNAV Instruction 9290.2A of February 27, 1968, assigning the responsibility for determining the material adequacy of the submersible to CNM.

d. CNM directed Bureau of Ships (BUSHIPs) to develop a permanent manual for certifying submersibles. NAVSHIPS 0900-028-2010, Material Certification Procedures and Criteria Manual for Manned Non-Combatant Submersibles, and the Revision of September 1968 was superseded by NAVMAT P-9290 dated June 1976. This instruction assigned Non-Combatant Submersibles and submarine oriented DSS System Certification Authority (SCA) to the predecessors of NAVSEA 92Q and Navy Diving Program SCA to the predecessor of NAVSEA 00C.

e. NAVSEA P-9290.1A was distributed upon the dissolution of NAVMAT in April of 1987. It was retitled System Certification Procedures and Criteria Manual for Deep Submergence Systems. This eventually led to the issue of NAVSEA SS800-AG-MAN-010/P-9290 dated 4 December 1990 (System Certification Procedures and Criteria Manual for Deep Submergence Systems) by NAVSEA 92 and NAVSEA SS521-AA-MAN-010 dated October 1987 (U.S. Navy Diving and Manned Hyperbaric Systems Safety Certification Manual) by NAVSEA 00C.

1.2.2 Lessons Learned

During the development of the DSSP, there were a number of mishaps which emphasized the importance of such a program. It also helped shape the program and improve the focus.

a. In 1968, the Handling System onboard the DSV ALVIN support ship, RV LULU, failed resulting in dropping DSV ALVIN in 4400 feet of water. The three people on board were able to escape. However, the last person out, who was injured in the incident, estimated ALVIN was 30 feet underwater at the time of escape. This led to certification requirements for handling systems.

b. In the early 1970s, two separate commercial incidents claimed three lives, the more well-known being the Johnson Sea Link entrapment. Two lives were lost when it became entangled on a scuttled destroyer. This led to greater consideration for preventing entanglement as well as affecting the design of atmosphere control systems, mission planning and procedural control.

c. In 1982, five divers lost their lives when a vacuum was inadvertently drawn on board USS GRAYBACK (SS 574). This led to redesign of diving systems to ensure a vacuum could not be drawn. It also led to ensuring NAVSEA 00C is involved in the design of submarine oriented diving systems, in the approval of diving equipment, and in NAVSEA 92 SCA surveys of diving systems when NAVSEA 00C deems it necessary. Additionally, it led to requiring safety analyses during design for all systems within the Scope of Certification (SOC).

d. In the late 1980s, two Navy submersibles had casualties which did not result in any injuries, but had the potential for serious implications. One DSS became entangled on the ocean floor when it began operating in an unauthorized area. In 1987 the other DSS lost buoyancy on sea trials after an overhaul as a result of a ballast tank valve being installed backwards. In 1987 a civilian submersible's viewport failed due to improper design resulting in the death of one of the operators. These incidents emphasize the need for properly designed systems, meeting design requirements, and operating, maintaining, and monitoring systems in accordance with approved procedures.

1.3 Certification Definitions

1.3.1 Deep Submergence System

Those systems and components which, when working together, provide the capability for manned underwater operations. Elements may include a manned vehicle, shore training facilities, designated support equipment, those systems that are a temporary or permanent part of a submarine that are used to disembark or recover personnel such as a Dry Deck Shelter (DDS) or Lockout Trunk, and handling equipment.

1.3.2 Deep Submergence System Personnel

In the context of this manual, DSS personnel are the occupants or operators of the DSS. The safety of personnel involved with the external handling and external equipment operation of the DSS is not covered by the certification process unless a danger to their well-being imperils DSS personnel.

1.3.3 Scope of Certification

The SOC of a DSS is comprised of those systems, subsystems and components and the associated maintenance and operational procedures required to provide maximum reasonable assurance that DSS personnel are not imperiled during system operations.

1.3.4 Scope of Certification Notebook

The SOC Notebook contains simplified diagrams which outline those structures, systems, subsystems, and equipment within the DSS SOC and may provide guidance to ensure compliance with the certification requirements.

1.3.5 Surveys

Initial and sustaining surveys verify the adequacy of the DSS for manned use to the limits for which certification is being requested or was issued. This is accomplished by examining Objective Quality Evidence (OQE), reviewing processes and procedures, and inspecting equipment to validate compliance with approved procedural, design, fabrication, test, and maintenance requirements.

1.3.6 Objective Quality Evidence

OQE is any documented statement of fact, either quantitative or qualitative, pertaining to the quality of a product or service based on observations, measurements, or tests which can be verified. Evidence will be expressed in terms of specific quality requirements or characteristics. These characteristics are identified on drawings, in specifications, and other documents which describe the item, process, or procedure. The following are circumstances where TELCON and E-MAIL correspondence are considered appropriate in support of OQE:

a. TELCON record which includes all of the following for each party cited in the TELCON record: dated original, photocopied, facsimile or electronic signature, legible name, and, command/activity and office/code.

b. E-MAIL printout which includes the transmission header containing the name, activity code and date of each originating, responding or forwarding party.

In each case, the document must stand alone with regard to its addressing of specific platform, system, component and condition along with proper citing of any applicable references or invoked requirements, and must include participation by the party(ies) possessing cognizance and approval authority for the subject matter.

1.3.7 Certification Survey Plan

The Certification Survey Plan (CSP) is a detailed checklist derived from the SOC. It expands each SOC item to identify the description of requirements and the supporting documentation to substantiate the requirements. The SCA utilizes the CSP as the basis for performing certification surveys. CSPs replace Pre-Survey Outline Booklets (PSOBs) which were previously used for this purpose.

1.3.8 Certification Package

The certification package consists of the OQE supporting conformance to certification requirements.

1.3.9 Certification

The process of certification application, review, survey and approval of all items and procedures within a DSS SOC that affect the safety of DSS personnel. Written statement attesting that an item, procedure or system meets specified requirements.

1.3.10 DSS Certification

DSS certification is the authorization granted by the SCA to operate a DSS within its prescribed parameters.

1.3.11 Letter of Certification

The Letter of Certification, issued by the SCA, states the terms and conditions of certification. The Letter of Certification may be in the form of a letter, message, or other formal correspondence.

1.3.12 Initial Certification

Initial certification is conducted on all DSSs procured for Navy use. It is granted by the SCA for a DSS following demonstration of material and procedural adequacy.

1.3.13 Sustaining Certification

To sustain certification, the DSS must be operated and maintained in the as-certified condition in accordance with the Letter of Certification.

1.3.14 Suspension of Certification

Suspension of certification is a prohibition on manned operation of the DSS until the cause of the prohibition has been resolved.

1.3.15 Reinstatement of Certification

The SCA will reinstate certification when the cause of the suspension has been thoroughly investigated and satisfactorily corrected, and the material and procedural adequacy of the DSS has been re-established.

1.3.16 Functional Audits

A functional audit is an audit of an activity performing SOC work. It is a review of policies, processes, controls, procedures, and associated functions used to perform specific certification related tasks. This audit supplements the DSS construction, availability and sustaining surveys performed using the CSP.

1.3.17 Technical Assistance Review (Tech Assist)

An overall or specific area review of certification related documentation, processes, or practices conducted at the request of the Program Manager. The purpose of the Tech Assist is to provide SCA guidance in support of the assigned DSS or facility certification.

1.4 Principal Participants

a. The DSS Sponsor identifies the program and funding requirements.

b. The Program Manager is the organization or activity that acts for the DSS Sponsor and provides overall program management direction.

c. The Sustaining Activity for a DSS is the recipient of the Letter of Certification. The Sustaining Activity maintains and operates the DSS in the as-certified condition per the Letter of Certification. The Sustaining Activity requests reinstatement of certification in the event the certification is suspended. In addition, the Sustaining Activity schedules the sustaining survey and provides the CSP.

d. The SCA is the code within NAVSEA assigned the responsibility for the manned DSS certification process by OPNAV. The SCA has final authority and responsibility for granting certification for DSSs covered by this manual. The SCA resides with the Deputy Commander for Submarines (NAVSEA 92). The working responsibility for certification is vested in NAVSEA 92Q.

e. The User Activity provides and exercises operational control for the DSS. In some instances the User Activity and Sustaining Activity will be the same.

f. The Cognizant Technical Authority is the organization which the NAVSEA Chief Engineer has designated as having the authority to represent the Chief Engineer on a specific technical area.

1.5 Basis for Initial DSS Certification

The basis for granting initial DSS certification is the SCA's satisfactory evaluation of the OQE supporting conformance to certification requirements, together with any certification surveys deemed necessary by the SCA. Mission reliability is of concern to

the SCA only to the extent that the DSS permits safe operation and/or recovery of DSS personnel without injury following a mishap. The ability of the DSS to meet program goals, other than safety, is not the objective of the DSS safety certification program.

1.6 DSS Certification Process

The certification process is iterative in nature and requires a continuing exchange of information between the Sponsor or the designated Program Manager, the Sustaining Activity and the SCA. During all phases of the certification process, the formal line of communication between the SCA, the Cognizant Technical Authority, and the Sustaining Activity is via the Program Manager. The Program Manager will inform the SCA and obtain concurrence on issues affecting the SOC and changes to certification requirements for which Program Manager approval is required.

1.7 Documentation Hierarchy

The applicable contractual document should specify this manual as the highest precedence for identifying SOC requirements and boundaries. DSS SOC material and boundaries may interface with SUBSAFE (NAVSEA 0924-062-0010) certification requirements and Diving and Manned Hyperbaric Systems (NAVSEA SS521-AA-MAN-010) certification requirements. The Program Manager should be notified of any conflicts between these documents for proper resolution. Silence of one document with respect to details shown in another document or in another section of the same document shall not be considered an inconsistency or conflict.

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Chapter 2
The System Certification Process

2.1 Introduction

a. The purpose of this chapter is to describe the certification process for new acquisitions, major and minor overhauls, modifications, sustaining certification, as well as the required documentation.

b. The certification process requirements are mandatory. In those cases where circumstances call for change or deviations from the prescribed process they will be documented and approved by the SCA via the Program Manager. The sequential events in the certification process are depicted in Figure 2-1 for Initial Certification and Figure 2-2 for Sustaining/Reinstatement of Certification.

c. In some cases the DSS may already be designed or built (including Nondevelopmental Items (NDI), COTs, etc.) and the certification process may need to be tailored. The basic process covered in this manual should be used as a guide. However, the Cognizant Technical Authority, Program Manager and SCA should use the available studies, tests, reports, and operational history as part of the certification process. This approach is not intended to reduce safety standards, but to use available information and facts to the maximum extent possible.

d. When modifications to DSSs are made, the general certification process covered in this manual should be followed.

2.2 Application for Initial Certification

The Program Manager must submit an application to the SCA for initial certification early in the acquisition or leasing process. For major modifications, the Program Manager will submit an application early in the development process identifying all SOC changes and impacts. NAVSEA 00C participation in diving and diving related certification shall be as defined in the applicable Memorandum of Understanding (MOU).

a. For DSSs which have yet to be built, or major modifications to be installed, the SCA and Cognizant Technical Authority should be involved in the concept phase. Their involvement should continue throughout the design and fabrication phase. However, in the context of this manual the certification process starts at the design phase. The application must contain, or address, the following elements:

(1) Identification of the principal participants;

(2) General description of the DSS;

(3) Desired mission profile including operational limits;

(4) If the DSS is leased, identification of the leaseholder and certification history;

(5) Plan of Action and Milestones (POA&M);

(6) System Safety Program Plan;

(7) Maintenance Plan;

(8) Proposed SOC;

(9) Proposed CSP, if available; and

(10) Proposed process for certification for unique situations.

2.2.1 Plan of Action and Milestones

The POA&M is a detailed list of planned actions and the sequential events in the certification process with estimated dates of completion. The time allowance for documentation submittals, technical reviews, and deficiency corrections must be considered in the POA&M to assure a timely completion of the certification process prior to the DSS desired use date. Close coordination between the SCA and the Program Manager is required to develop a practical, workable POA&M.

2.2.2 System Safety Program Plan

The System Safety Program Plan describes the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate hazards to the DSS personnel, or reduce the associated risk to an acceptable level throughout the system life cycle. The Builder/Program Manager shall submit a System Safety Program Plan, tailored to the needs of their specific DSS. MIL-STD-882, System Safety Program Requirements, provides guidelines that can be followed for System Safety Program Plan development.

a. As a minimum, the following areas must be addressed in the plan for initial and sustaining certification:

(1) Preliminary hazard analysis during system design and development phase to help identify major potential system design flaws.

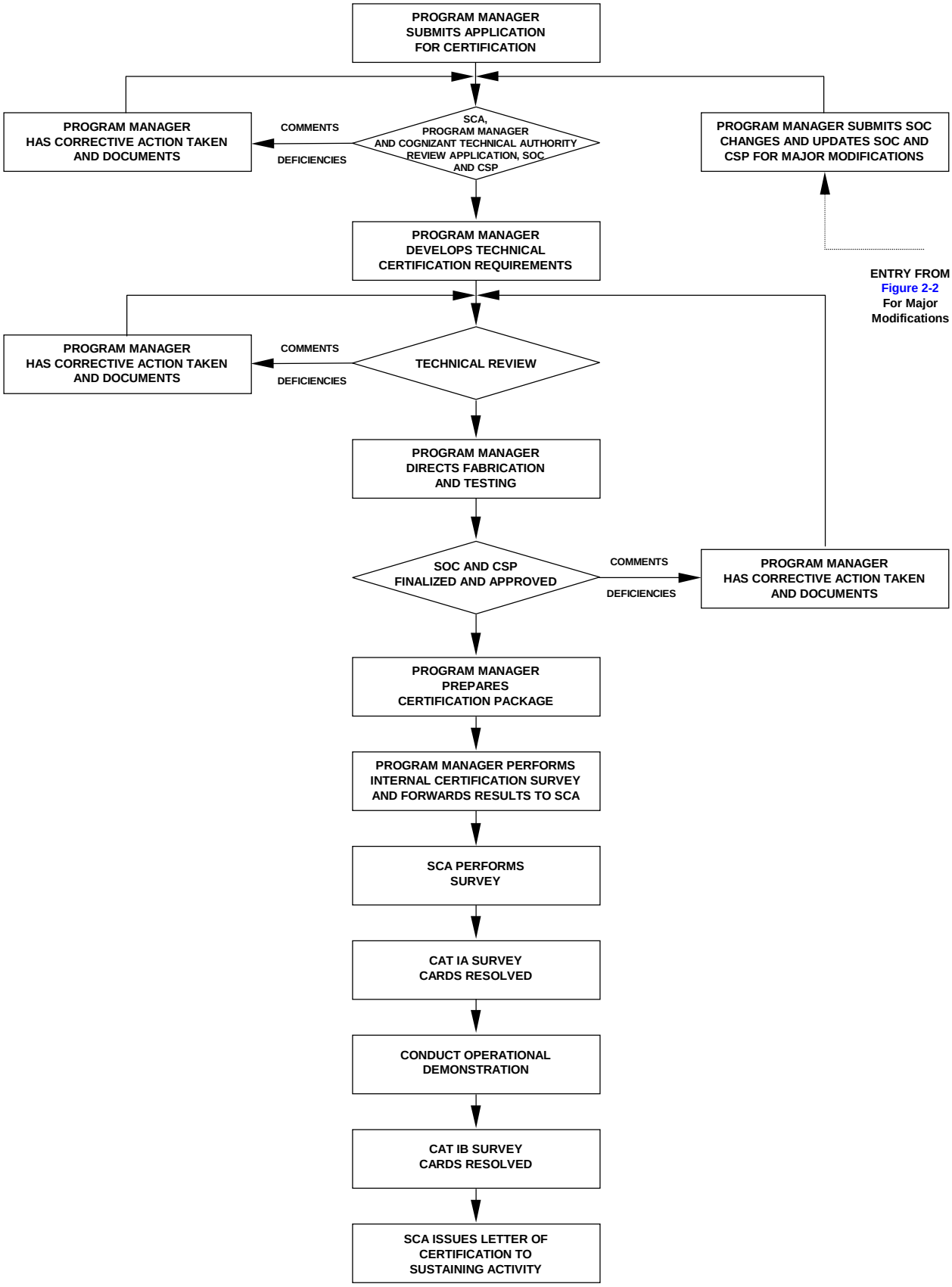

Figure 2-1. Initial Certification Process

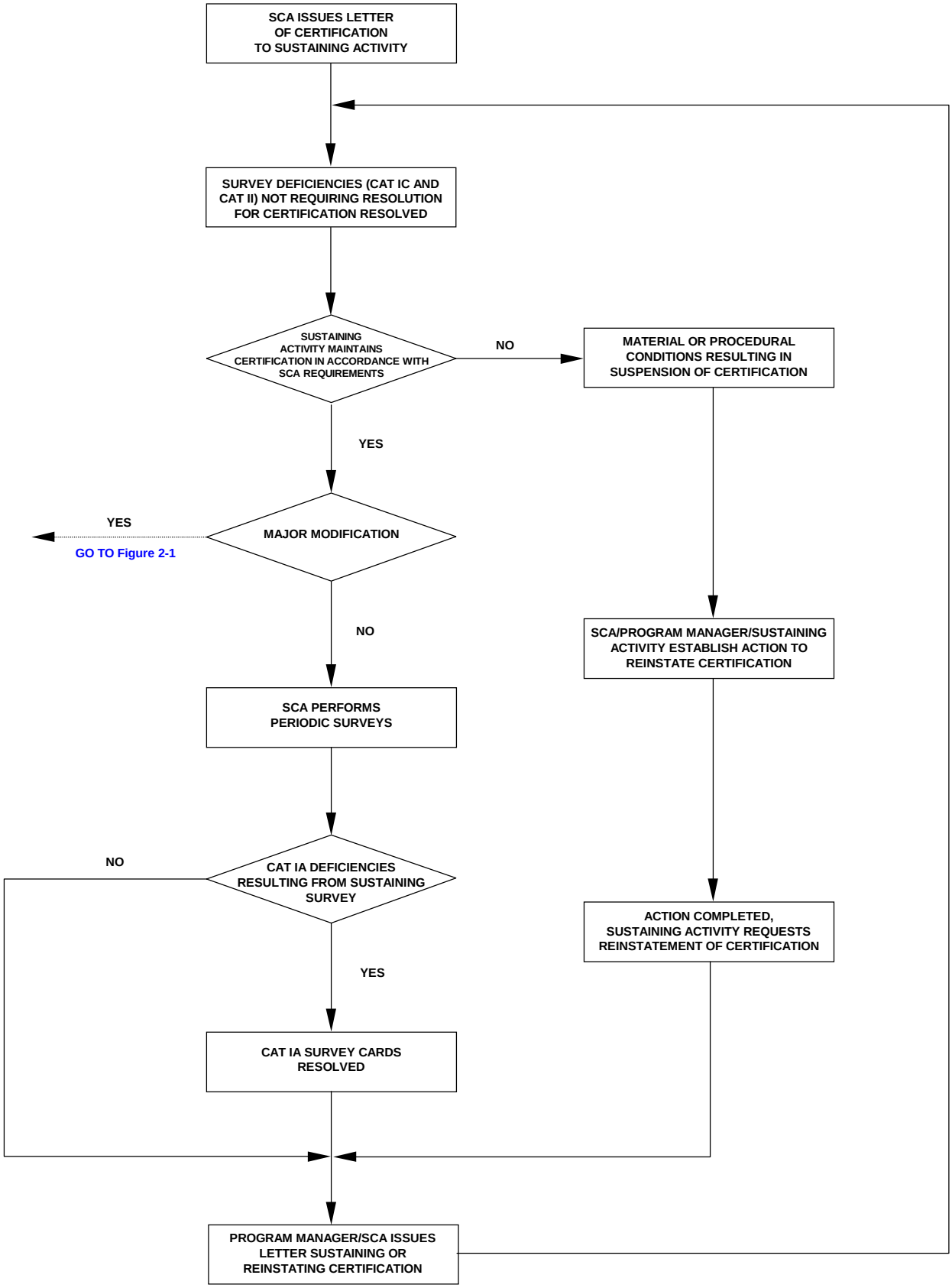

Figure 2-2. Sustaining/Reinstatement of Certification Process

(2) System hazard analysis. It shall:

(a) Identify possible failure modes including all single point failures during any operational sequence.

(b) Describe the effect of the failure on the specific operational event during which it occurs.

(c) Describe the effect of the failure, if any, on subsequent operation(s).

(d) Provide recommendations for the necessary corrective action.

(3) Subsystem hazard analysis. It shall:

(a) Identify possible failure modes including all single point failures during any operational sequence.

(b) Describe the effect of the failure on the specific operational event during which it occurs.

(c) Describe the effect of the failure, if any, on subsequent operation(s).

(d) Provide recommendations for the necessary corrective action.

(4) Operating and Support Hazard Analysis (O&SHA), if appropriate.

(5) System safety personnel qualifications.

(6) Safety Compliance Assessment to evaluate the safety risk being assumed prior to system test or operation at the conclusion of the contract and prior to initial operational capability.

(7) Hazard tracking and closeout (resolution) plan.

(8) Final hazard analysis update to reflect any changes made to the system hazard analysis and reflecting the final DSS design.

b. The results of these analyses should provide one of the primary sources for determining which items within the DSS should be included in the SOC.

c. The previous paragraphs assume the system or DSS which is being studied is not yet built. However, for new acquisitions which are already built, modifications, SHIPALTs, Temporary Modifications (Temp Mods), etc., the complete system or portions of systems and equipment may already be built, or available commercially. In these cases, it may not be reasonable to conduct the full range of tasks for a safety

study. In these cases, the System Safety Program Plan may be tailored to address only aspects necessary to protect DSS personnel safety.

2.2.3 Proposed Scope of Certification

The proposed SOC is developed by the Design Agent/Program Manager and is submitted to the SCA with the application. It consists of all applicable portions of the DSS and its ancillary equipment required to provide assurance for DSS personnel safety. Components, systems and portions of the DSS and special instructions that require inclusion in the SOC are:

a. Those systems/equipment where failure creates an immediate hazard resulting in injury or death.

b. Those which, through failure to operate properly, could prevent the safe return of DSS personnel to the surface, or with certain systems, to a submerged base;

c. Those required to maintain DSS personnel safely on the surface;

d. Those provided to rescue personnel from the DSS and return them to the surface, support ship, submerged base, or, in special cases involving hyperbaric chambers, to ambient conditions outside the chamber;

e. Those associated with Temp Mods affecting trim and stability conditions, both surfaced and submerged, that could threaten safe recovery of personnel;

f. Normal and emergency operating procedures, including pre-dive and post-dive procedures, for systems within the SOC; and

g. Maintenance procedures for systems, subsystems, and components within the SOC.

2.2.3.1 Scope of Certification

Since individual DSS designs may vary extensively, no single list of SOC items will encompass the entire spectrum to cover every SOC. Each item and system within the DSS must be evaluated by the Program Manager to determine SOC applicability. The listing of systems shown below which may require certification is provided for purposes of illustration and should not be considered all inclusive or universally applicable.

a. The pressure hull, pressure vessels, hard structure, and appurtenances.

b. The ballast systems if used for normal or emergency surfacing.

c. Jettisoning and emergency blow systems that can be used to return the DSS to the surface in the event of an emergency.

d. All modes of life support systems which provide an acceptable atmosphere to DSS personnel.

e. Noncompensated equipment, subject to pressure, which may implode or explode (see Appendices C and D).

f. Release devices for external appendages, if required for DSS personnel safety.

g. Fire fighting devices or systems.

h. Communication systems that enable personnel utilizing the DSS to communicate with support personnel.

i. Monitoring/detecting devices which will be depended upon to ensure that DSS personnel are safe and do not exceed the DSS certified operating limits.

j. External obstacle avoidance systems, such as active sonars, fathometers, passive sonars, TV viewing systems, optical viewing devices, and periscopes.

k. The propulsion system for submersibles operating under or near overhangs, cliffs, in canyons, or when operating scenarios require propulsion to ensure operator safety.

l. Accessibility to vital equipment required for normal safe DSS operation and which actuates recovery or emergency systems, including systems which may be required for recovery of personnel from the DSS following a casualty.

m. Flotation or buoyancy of the DSS whose failure or inadequacy could adversely affect the hydrostatic equilibrium of the DSS, which would prevent safe recovery of DSS personnel.

n. Internal and external electrical protective devices whose failure could result in the malfunction of a critical component/system or could result in any electrical equipment becoming a shock hazard to DSS personnel. Electrical equipment and accessories which have sufficient electrical potential to cause a hazard to DSS personnel and are not equipped with an electrical protective device are within the SOC from an electrical safety standpoint only. Any other electrical equipment or accessories which are not in the SOC for operational reasons shall not be classified as SOC equipment.

o. Written operating, emergency and maintenance procedures including pre-dive and post-dive procedures for the particular DSS.

p. Support ship or DSS handling systems and components when the DSS is handled with personnel aboard (man rated). Appendix H has additional guidance.

q. All material in manned spaces for toxic and flammable material identification. Any material not in the SOC for operational reasons shall not be considered SOC equipment. Appendix F has additional guidance.

NAVSEA SS521-AA-MAN-010, U.S. Navy Diving and Manned Hyperbaric Systems Safety Certification Manual, provides SOC requirements for diver equipment. This may include the systems, subsystems, components, and portions of the equipment located on the diver side of the umbilical or supply hose connection required to ensure and preserve the safety and well-being of the diver. Where these systems interface, the respective Program Managers and SCAs will establish the requirements for certification.

2.2.3.2 Scope of Certification Notebook

The SOC Notebook delineates pertinent certification maintenance procedures within the DSS SOC. The intent of the SOC Notebook is to clearly define the exact areas within the SOC, identify all certifiable items, and provide reference to the related engineering drawing data.

2.2.3.3 Memorandum of Understanding

a. If there is a departure from the principal participants or responsibilities stated in Section 1.4, then a MOU shall be prepared which defines the relationships between the principal participants in the certification process.

b. The Sustaining Activity is responsible for ensuring that a written agreement is invoked between each activity that is performing work within the SOC. These written agreements shall precisely delineate the responsibility of each activity for all phases of work being performed and shall be agreed to by all parties involved prior to processing the work documents used to control the SOC.

c. All MOUs shall be signed by the participants.

2.2.4 Certification Survey Plan

The DSS CSP is derived from the DSS SOC, the specifications and detailed drawings. As directed by the Program Manager, the CSP is developed to address the specific SOC items of the DSS. After Program Manager/SCA approval and use of the CSP for initial certification, any subsequent changes shall require Program Manager and SCA approval. It identifies the areas and items to be surveyed and provides a summary of the requirements that must be satisfied to achieve and sustain certification,

thereby ensuring that the invoking specifications require the correct supporting OQE to satisfy the SCA survey requirements. For all subsequent certification surveys the Sustaining Activity and the Program Manager will annotate the CSP to reflect the work accomplished, modifications made since the previous survey, OQE, and applicability for each line item. Each activity will annotate the CSP for all items for which the activity is responsible. The annotated CSP shall be submitted for information at least 30 days prior to the survey, or as directed by the Program Manager. All changes to the CSP other than changes to the documentation to substantiate requirements require SCA approval. Appendix K provides the format and direction for preparation of the CSP.

2.3 Approval of System SOC Documents

The Program Manager will review and, with SCA concurrence, approve the SOC documents which define the SOC boundary and invoke SOC requirements to ensure the overall DSS certification requirements are identified. Deficiencies, differences and problems will be resolved by the Program Manager to ensure the requirements of the certification process are met. The Program Manager shall submit up-to-date copies of the requested drawings for each SOC component and system to the SCA and Cognizant Technical Authority for evaluation and review, respectively. The only exception to this is addressed in Section 2.2.4.

2.4 Departure From Specification

In the context of DSS SOC, a Departure From Specification (DFS) is a non-conformance of any certification attribute from the intended or as-certified condition of the DSS. This includes non-conformances to approved drawings, component specifications, technical manuals, operating and emergency procedures (OPs/EPs), maintenance procedures, and any other authoritative document specifying a certification attribute of the DSS. A DFS shall be identified as a deviation or waiver as follows:

Deviation - a DFS which is requested prior to a planned non-conformance.

Waiver - a DFS which is requested subsequent to the non-conformance occurring.

Departures are categorized as Major or Minor based on the following criteria:

a. Major - A DFS that affects:

(1) Performance;

(2) Durability;

(3) Reliability or maintainability;

(4) Interchangeability;

(5) Effective use or operation;

(6) Weight or stability;

(7) Health or safety;

(8) System design parameters such as schematics, flows, pressures, or temperatures;

(9) Compartment arrangements or assigned function.

b. Minor - A DFS that does not meet the criteria for a Major DFS.

2.4.1 Processing Departures From Specification

All DSS SOC DFSs require Program Manager approval with SCA concurrence prior to manned use. The Program Manager with SCA concurrence may delegate:

- authority to approve system specific routinely recurring DSS SOC DFSs, whether major or minor.

- authority to approve minor DSS SOC DFSs.

All SOC waivers or deviations, whether identified as major or minor in scope, must be forwarded to the Program Manager and SCA for information.

DFSs for each period of DSS development and operation shall be administered in accordance with the following requirements:

a. New Construction - The requirements of this manual as extended and amplified in a separate document agreed upon by the Design Agent/Builder and the Program Manager, with SCA concurrence.

b. Overhauls - The requirements of this manual as extended and amplified by the applicable Overhaul Work Package and local policy documents as agreed upon by the Program Manager, with SCA concurrence.

c. Operational - The requirements of this manual as extended and amplified by Sustaining Activity directives or a separate document agreed upon by the Sustaining Activity and the Program Manager, with SCA concurrence. The following requirements apply:

(1) Should any system, equipment, or component within the SOC fail to operate within specifications, regardless of how the deficiency is discovered, and repair at the Sustaining Activity level is not practicable prior to a planned underway period, a Major DFS shall be submitted.

(2) As a minimum, all DFSs within the SOC must contain specifics as to which specification cannot be met, any proposed temporary change to the OPs/EPs required as a result of the deficiency, and a statement of impact on the ability of the system to operate safely. All DFSs within the SOC must be approved prior to continuing manned operation of the DSS.

(3) When the DSS is at sea, the Commanding Officer or Officer in Charge (OIC) will evaluate all DFSs to determine the corrective action to be taken and any restrictions necessary. The decision to continue manned operation of the DSS shall be made only after a careful review of the impact the deficiency will have on DSS personnel safety under all normal and emergency conditions. A report to the Program Manager via the chain of command will be made at the first opportunity. As a minimum, the report shall contain a description of the condition as well as the intended action. If continued operation of the DSS is intended, the report shall include a statement of impact on the ability of the system to operate safely, specifics on any required temporary local changes to the OPs/EPs made as a result of the deficiency, and any imposed operating restrictions. If the condition is not corrected during the next in-port period, a DFS shall be forwarded for approval prior to the next manned use of the DSS.

2.4.2 DFS Administrative Control and Records

All activities involved with DSS SOC waivers or deviations shall ensure the following administrative instructions are followed and integrated into applicable process instructions used by each representative activity:

a. Each activity must maintain a log of all waivers and deviations generated by that activity. This log (or computer program equivalent) of all DFS requests shall be maintained for each DSS. Departures within the SOC shall be annotated "SOC" on the departure and in the log.

(1) The Sustaining Activity shall maintain a master departure log of all waivers and deviations approved for each DSS. The log shall contain, as a minimum, the following:

(a) DSS unique identifier (name, hull no., serial no., etc.)

(b) Departure number.

(c) Departure title.

(d) Classification (Major or Minor).

(e) Type of departure (deviation or waiver).

(f) Date requested.

(g) Date resolved.

(h) Approval or disapproval status.

(i) Conditional approval comments (if applicable).

(j) Impact on design review.

(k) A copy of all applicable NAVSEA correspondence delegating local approval of DFSs.

Each activity shall maintain all departures in a form suitable for audit including supporting justification, technical documentation, calculations, rationale, and related correspondence. NAVSEA shall perform a periodic audit of the departure records for NAVSEA activities. Other activities shall perform a periodic audit of the departure records for their activity.

b. A copy of the waiver or deviation shall be forwarded to the applicable asset and its planning yard. This applies to both approved and/or disapproved waivers or deviations to ensure the planning yard is kept fully informed and maintenance of the asset historical file.

c. All conditionally approved waivers and deviations shall be tracked by the cognizant originating activity and the Sustaining Activity until the condition is either cleared or added to the applicable technical document as an acceptable condition.

2.5 Technical Certification Requirements

a. The Program Manager and SCA will verify the accuracy and completeness of the SOC Notebook and the CSP developed or updated by the Sustaining Activity/industrial facility. The Sustaining Activity/Program Manager is responsible for specifying the items to be surveyed and, for each item in the SOC, the specifications, description of requirements and documentation required. The SOC Notebook, OPs/EPs, drawings, and any other documentation requested by NAVSEA will be submitted for review and evaluation to the Cognizant Technical Authority as determined by the Program Manager. Any deficiencies resulting from this review will be resolved by the Program Manager.

b. The Program Manager shall ensure that the DSS operators have the latest version of documents. Redlined marked-up technical data such as drawings, SOC Notebook, OPs/EPs shall be available prior to manned use of the DSS.

2.6 Certification Package

The Sustaining Activity, maintenance facility or industrial facility, as appropriate, will use the approved CSP to assemble and account for all supporting OQE required for the internal and SCA certification surveys.

2.7 Internal Certification Survey

The Program Manager/Sustaining Activity will initiate and support an internal certification survey that covers all applicable elements of the CSP for initial certification, sustaining certification and reinstatement of certification. The Sustaining Activity/industrial facility will document the findings of this survey and identify corrective actions. The internal survey report and the current status of the findings relative to corrective actions taken will be forwarded to the SCA. Additional guidance on surveys is contained in Chapter 4.

2.8 SCA Surveys

Prior to initial certification, the SCA will conduct surveys to determine compliance with approved design, fabrication, and test requirements and to verify adequacy of the DSS for manned use to the limits for which the certification is being requested. The SCA will prepare and forward the survey report to the Program Manager for action. The Program Manager will assign responsibility for corrective and preventive action to resolve any recommendations. Subsequent to initial certification, periodic follow-up certification surveys shall be performed by the SCA or his designated representative as a condition of maintaining or continuing certification. The periodicity of the SCA sustaining surveys will be adjudicated between the Program Manager and the SCA and will be based upon the results of the last survey performed by both the Sustaining Activity and the SCA. Additional guidance on surveys is contained in Chapter 4.

2.9 Operational Demonstration

Operational demonstrations are events to demonstrate functioning of installed equipment applicable to the DSS and its mission. The Program Manager and SCA require an operational demonstration to be conducted for new acquisitions prior to initial certification. In addition, for major modifications to existing systems and following overhaul or an extended maintenance period, an operational demonstration is required prior to reinstatement of certification. The SCA or a designated representative will participate in the operational demonstration. The operational demonstration procedures shall require SCA and Program Manager approval. The operational demonstration and trials stages are further described in Section 3.7.

2.10 Issuance of Certification

Once the process for certification or reinstatement of certification is successfully completed, the SCA will issue a Letter of Certification to the Sustaining Activity. The letter will state the terms and conditions of the certification.

a. If during the certification or reinstatement of certification process, any required testing or demonstrations required to verify a capability are not performed, the Letter of Certification shall specify the resulting restrictions imposed on the DSS. For example, if the maximum depth of the DSS was not reached on the initial certification dive or as needed for retests on sea trials, the letter would specify the maximum depth reached as the limit for the DSS. Subsequent SCA approval would be required to dive to the maximum depth of the DSS, as well as a new Letter of Certification.

b. The Letter of Certification should:

(1) Indicate the requirements the DSS is certified to.

(2) Indicate the DSS is materially and procedurally adequate.

(3) Provide operating limits or restrictions.

(4) Provide requirements for sustaining certification.

(5) Provide/reference the DSS SOC.

(6) Provide the date for the next survey.

(7) Reference the NAVSEA approved OPs/EPs.

2.11 Sustaining Certification

a. The Sustaining Activity for the DSS must maintain the system in the as-certified condition in accordance with the Letter of Certification. Any configuration change within or to the DSS SOC must be approved by the Program Manager with SCA concurrence. Chapter 5 of this manual provides additional guidance.

b. Following satisfactory resolution of any sustaining survey deficiencies, the Program Manager shall issue a letter indicating that all certification requirements have been sustained. It provides the date for the next certification survey. It shall also include the internal survey requirements when different from the requirements of this manual.

2.12 Modifications

a. Major Modifications:

Once the SOC is approved by the SCA, all permanent modifications that in any way change or alter those items addressed in the DSS SOC shall be submitted to the SCA for evaluation. This would also include the addition of components, systems, or portions of systems which meet the intent of Section 2.2.3. Submission of the modification will be subject to the same review and approval process required for initial certification. Figures 2-1 and 2-2 provide the evaluation and review processes that must be considered when alterations or modifications are accomplished within the SOC.

b. Temporary Modifications:

Temp Mods are components, systems, or subsystems required for test and evaluation, research and development programs or in support of mission or exercise requirements. The requirements for certification are contained in Section 5.4.4.

2.13 Suspension of Certification

The certification for a DSS will be suspended when any of the following events causes a reduction in the material or procedural adequacy of the DSS:

a. Violation of any of the terms or conditions of the Letter of Certification;

b. Recognition of the existence of an unsafe condition; or

c. Overhaul or equivalent maintenance period.

The SCA and Program Manager will determine if a formal suspension of certification is required based on the planned scope of work during a maintenance period. If reinstatement of certification will be required at the end of a maintenance period, formal suspension of certification is required.

When certification is suspended, the Program Manager, with SCA concurrence, will formally specify the requirements for reinstatement of certification.

2.14 Functional Audits

NAVSEA functional audits will be conducted periodically on activities which routinely perform work for DSS SOC. These audits are designed to review processes, controls, procedures and associated functions used to perform specific SOC related tasks. Functional audit results provide all levels of management at the activity with an independent, objective and constructive evaluation of the effectiveness and efficiency

with which quality assurance and control responsibilities are being implemented and followed. The Program Manager, SCA and the activity being audited will determine the scope and frequency of the audits. The SCA will develop (define) an audit plan.

2.15 Process For Changing The Manual

2.15.1 Change Submittal

Users of this manual are encouraged to submit change requests. Recommended changes to this manual shall be documented on the Manual Change Request (MCR) Form included in the manual and shall be submitted to NAVSEA 92Q for resolution. Change requests shall include specific recommended change wording, with detailed rationale or justification. Change requests shall also identify known impacts of the recommended change upon related reference documentation. If changes are submitted in electronic format, facsimile or E-MAIL, each change request shall contain the information required on the MCR Form. Participation in the change process is both important and appreciated.

2.15.2 Change Status Accounting

A master change status accounting system shall be maintained by NAVSEA 92Q to track all requests for proposed changes to the manual. As a minimum, the system shall identify the item and shall contain the review status, evaluation comments, and resulting action.

2.15.3 Manual Distribution

As custodian of the manual, NAVSEA 92Q maintains control over its distribution. To ensure adequate distribution and change management, the names, codes, and activities of authorized manual holders, by copy number, will be reported to NAVSEA 92Q, as solicited. Requests for additional or replacement copies of the manual, with supporting justification, should be directed to NAVSEA 92Q.

Chapter 3
Requirements for Certification

3.1 Introduction

This chapter describes the required OQE the Program Manager must develop for the SCA to review, for initial certification, reinstatement of certification, as well as to sustain certification. Due to the uniqueness of some commercially available items and systems, the specifications and OQE requirements invoked in this manual may be modified, with Program Manager approval and SCA concurrence, for the item or system. The OQE includes the following areas:

a. Design and Configuration Management.

b. Material Control.

c. Fabrication Process Control.

d. Quality Assurance.

e. Test Performance.

f. Operational Demonstration and Trials Stage.

g. Operating and Emergency Procedures.

h. Maintenance Procedures.

Specific requirements for each of these areas are described in the remainder of this chapter.

3.2 Design and Configuration Management

The original design of any system or the design change/improvement to any new or existing system that will be part of the SOC shall be approved by the Program Manager. It is the responsibility of the Program Manager to ensure that the DSS SOC design, and any changes to that design, have been reviewed and concurred with by the Cognizant Technical Authority and the SCA.

The OQE addressing the design or design change/improvement of the DSS shall include the following as a minimum:

a. Summary description of the DSS.

b. Design parameters.

c. Subsystem descriptions.

d. Design analysis and calculations, as appropriate.

e. System diagrams or top level drawings, as applicable.

f. Operability and maintainability criteria and procedures.

g. Justification of materials.

h. Toxic and flammable materials.

i. Atmosphere analysis.

j. Analysis for vacuum in manned and floodable spaces.

k. System Safety Program.

The Program Manager will ensure the availability of the necessary supporting drawings, calculations and related data to allow in-depth assessment of the design or configuration change. In some cases this documentation may be related to other support systems or components that, while not within the SOC, impact the system design or configuration change review.

3.2.1 Summary Description of the DSS

To aid the SCA in performing a safety assessment, the Program Manager shall submit a summary description of the DSS including design and construction approach and a mission profile. There shall be a written explanation of the features of the system along with appropriate schematic drawings to show operating and functional relationships during manned operation.

3.2.2 Design Parameters

The design parameters set by the Program Manager must be identified to the SCA because the design parameters provide the basis for evaluation of design adequacy for certification. General design parameters for a DSS that the SCA will consider for evaluation include:

a. Type of life support equipment.

b. System displacement/volume/weight changes.

c. Manning requirements.

d. Design safety factors.

e. Design life and service period (useful life, number of cycles, etc.).

f. Effect of ambient operating conditions, mechanical shock and vibration on design life.

g. Replacement/replenishment requirements.

h. Depth/pressure limitations.

i. Correlation with the mission profile (scenario) including the supply requirements to support the maximum dive duration.

j. Limits for breathing gas composition, pressure and flow, temperature and humidity.

k. Specification of breathing gas contamination limits.

l. Temperature/humidity limits for both normal and emergency operating conditions.

m. Thermal and electrical protection requirements.

n. Results of the System Safety Program analyses.

o. Emergency equipment requirements and capabilities.

p. Communications requirements.

q. Corrosion allowance/protection requirements.

r. Operational sea state (launch, recovery, operational).

s. Lifting and weight handling requirements.

3.2.3 Subsystem Descriptions

Each subsystem within the DSS will be described. Sufficient information shall be included to identify the specific components, their location, orientation, and size. The descriptions shall include fluid systems (including compressed air and gas systems), electrical systems, as well as mechanical and structural features. A function/flow diagram shall also be developed and provided. The description must clearly delineate objectives of the design and include safety considerations.

3.2.4 Design Analysis and Calculations

A design analysis of the DSS must be submitted for Program Manager acceptance with SCA and Cognizant Technical Authority concurrence. The appendices provide design considerations and guidance that must be evaluated during the certification process. The design analysis will include formal design calculations including a complete stress analysis as appropriate.

3.2.4.1 Design Calculations

Calculations will be submitted to the Program Manager to demonstrate the adequacy of design in terms of the design parameters of the DSS, and with all assumptions clearly stated. Components, equipment and systems shall be designed to properly operate at the most limiting design conditions. Information will be submitted in sufficient detail to permit independent analysis of the design. Documentation submitted by the Program Manager shall be tabulated to ensure that the information completely covers the design.

a. Structural design calculations shall show the effect of fabricating to worst case dimensions and tolerances. Potential effects of corrosion caused by galvanic interaction of dissimilar metals and stress corrosion cracking must be considered. Appropriate reference shall be made to applicable test data or operating experience when either is used to support a calculation technique.

b. Piping and mechanical systems shall have calculations to show the capability of the system to perform its intended function. This includes system flow characteristics, velocity, and storage and/or air bank capacity, where applicable.

c. Design calculations for electrical equipment and systems will contain as a minimum:

(1) Electrical load calculations.

(2) The maximum current wires will carry and the heating effect of such current on the wire and insulation.

(3) Maximum heat generated by the equipment, and the maximum anticipated temperature.

(4) Where available, information obtained from the manufacturers of the electrical/electronic equipment may be used in lieu of actual calculations.

3.2.4.2 Stress Analysis

The adequacy of the design must be supported by detailed stress analysis, performed by assuming the DSS worst case mission scenario. Pipe hangers and supports, including sound isolated type, shall also be part of the stress analysis. Appropriate sections and provisions of pressure vessel design and piping design standards shall be identified and applied.

a. Tests and test programs in support of certification shall be used to validate the results of the stress analyses when warranted.

b. Stress analyses and test reports submitted by the Program Manager shall consider the most critical loading case (worst case), which includes the cumulative detrimental effects of design allowances, dimensional variations, and tolerances. Examples of loads to be considered are:

(1) Forces encountered during hydrostatic testing.

(2) Forces encountered while transporting, securing, removing, or handling the DSS or its components.

(a) Vibration transmitted from the shipping platform transporting the components of the DSS.

(b) Vertical and horizontal loads and moments on foundations.

(c) Forces developed by shipboard accelerations imposed by ship motions.

(3) Static loads imposed by the devices used to secure the DSS.

(4) Maximum operating pressure of gas within the DSS.

(5) Thermal stresses due to the maximum operating temperature range of the DSS.

(6) Reactions due to differential thermal expansion between the DSS and the structure to which it may be fixed or to elastic expansion of the DSS caused by internal pressure.

(7) Shock, including accidental blows.

(8) Dynamic loads, such as those encountered:

(a) When launching, retrieving, or handling a DSS.

(b) When bottoming a DSS at normal rate of descent.

(c) In normal or casualty operations such as explosively jettisoning external equipment.

(d) When surfaced, a wave slap load of ± 1000 psf.

(9) Worst case hydrodynamic loads imposed under both normal and emergency operating conditions. Additionally, if the DSS is attached to a host platform then the DSS shall be designed to withstand those hydrodynamic loads which are a result of the most severe host ship maneuvers while the DSS is aboard.

(10) Fatigue load life of the pressure-resisting components and piping for a specified number of cycles in a cold water environment.

3.2.5 Drawings

Certification of all DSSs shall require review and approval of specific top level drawings and diagrams by the Program Manager with SCA concurrence. Changes to SOC attributes on top level drawings and diagrams require Program Manager approval. Top level drawings and diagrams are the highest level drawings which define unique SOC requirements. A drawing index should be prepared for Program Manager approval and SCA concurrence that will include and identify all SOC drawings and diagrams. As determined by the Program Manager with SCA concurrence, the drawing index will reflect the appropriate approval level necessary for each drawing and diagram.

Documents listed in the drawing index must be adequate to support a detailed technical design review. Drawings and diagrams shall also be prepared to support manufacture, fabrication, modification and life cycle support.

Each component or item on a drawing is to be identified by the manufacturer's model or type number, part number, vendor identification, applicable specification, or as otherwise approved by NAVSEA. All components that provide a control, sensing or variable control function impacting on the operation of the system (valves, gauges, filters, meters, heaters, coolers, etc.) shall have a designated symbol and number assigned and be shown on the drawings and diagrams. Each component shall be identified to the level necessary to procure or manufacture an identical component.

At the completion of an overhaul or other availability, the maintenance facility or industrial facility is responsible for providing redline mark-ups of all required drawing changes to the Design Agent and the Sustaining Activity. It is the responsibility of the Program Manager and the Sustaining Activity to keep SOC drawings and diagrams up-to-date throughout the service life of the DSS.

3.2.6 Operability and Maintainability

The maintenance concept for DSSs involves a number of short to medium length availabilities and may also include extended major maintenance availabilities. The Program Manager shall ensure that operability and maintenance of the DSS is considered during the design process. Any operability and maintainability concerns identified during the design process shall be incorporated, as appropriate, into the design, into the OPs/EPs or into the maintenance procedures.

The Program Manager, Cognizant Technical Authority, and Design Agent as appropriate will evaluate all modifications, Temp Mods and alterations to the DSS for impact on the SOC and inclusion in the OPs/EPs and maintenance procedures. Related documentation will be retained and validated during sustaining certification surveys. Sections 3.8 and 3.9 provide additional information.

3.2.7 Justification of Materials

All materials within the SOC and their applications used in the design of a DSS shall be justified. Selection of materials will be consistent with the stated operating environment.

a. It is anticipated that some systems will be designed to operate in more severe environments than others and that new materials and configurations may be employed. It is not the intent of this manual to limit materials and their applications. The intent is to permit the use of new materials or time-tested materials in new applications whenever sufficient data exists to ensure the material adequacy of the system so that safety of the personnel using the system is not jeopardized. Justifying data must include the requirements for care, preservation and maintenance of new materials for the duration of the projected life cycle of the material.

b. The less available the information and experience with a given material and its application, the greater the burden upon the Program Manager to justify the proposed material application.

c. Material selection, design, and fabrication techniques shall be justified in accordance with best-recognized engineering practices. Proper consideration shall be given to complex configurations and intersections, cyclic fatigue and low temperature requirements as appropriate for a man-rated DSS.

d. For the purpose of certification, possible materials and/or components are addressed in Appendix A.

3.2.8 Toxic and Flammable Materials

The Program Manager shall develop a list of all potentially toxic and/or flammable materials used in construction and/or modification of a DSS.

a. For initial design and construction of the DSS, a Composite List of Non-metallic Materials tested for toxicity and flammability should be developed. During the life cycle of the system as new and alternate materials are tested and rejected or installed, the list shall be kept continuously updated by the Program Manager to reflect system configuration.

b. The composite list should contain the following data items for each material that undergoes toxicity or flammability testing:

(1) Material identity.

(2) Drawing and piece number or equivalent vendor description.

(3) Toxicity test results.

(4) Toxicity test report number.

(5) Flammability test results.

(6) Flammability test report number.

(7) Components which are tested for flammability and/or toxicity as complete assemblies shall be identified to the maximum extent possible. The drawing or equivalent vendor description shall be provided as well as the toxicity and flammability results, as well as test results. The quantity, location and use shall also be specified.

(8) NAVSEA approval document number if applicable.

(9) Comments (to include other pertinent information and any usage restrictions).

Since the materials either meet requirements for installation, are rejected, or have Program Manager approval, the list does not require NAVSEA approval.

c. Appendices A and B provide requirements for materials. Toxicity and flammability testing are addressed in Appendix F.

3.2.9 Atmosphere Analysis

Prior to manned use of a DSS, an analysis of the system atmosphere must be submitted for review (see Appendix F). In the event that toxicity testing has not been accomplished on any or all materials to be installed, an atmosphere analysis may be acceptable with SCA approval.

3.2.10 Vacuum in Manned and Floodable Spaces

All spaces designed for human occupancy that can be flooded shall be designed to prevent or minimize the possibility of unintentionally causing a pressure of less than one atmosphere while the chamber is occupied. If the design of existing chambers is such that the potential for unintentional depressurization of the chamber exists, then operational and emergency procedures addressing this hazard and providing specific instructions to prevent its occurrence while the chamber is occupied must be developed. The NAVSEA SCA for diving systems shall be involved in reviews of designs and concur in the final design of these systems, as well as be invited to participate in surveys of these systems.

3.2.11 System Safety Program

See Section 2.2.2 for a description of the System Safety Program requirements that must be submitted.

3.3 Material Control

This section establishes the minimum material process controls and OQE attributes that must be satisfied for all materials within a DSS. All items within the SOC require controls to provide assurance that the correct material is installed. All activities involved in construction, overhaul, repair or maintenance must ensure that the correct material is installed in the DSS.

Material Control Divisions (MCDs) will be used to define levels of control and OQE within the SOC. Material will be controlled as MCD A, B or C depending upon its application within the SOC. These divisions have been established to guide all activities in determination of the material OQE attributes and controls to be complied with to support certification. The activity shall establish the necessary control processes in accordance with the requirements of this manual, for procurement, receipt inspection, identification, storage, and installation of the material during construction, overhaul, maintenance, repair and alterations of the DSS under their cognizance. If an equivalent material control program is in place, to control program cost, the Program Manager with SCA concurrence may elect to utilize the existing material control processes in lieu of developing a new material control program.

The appropriate MCD category for each item shall be indicated on the NAVSEA approved "List of Material" or "Component List" which may be part of drawings and diagrams or may be a separate document. An extra column provided adjacent to the listed materials or components, designated "MCD", will contain the appropriate MCD designator "A", "B" or "C" as appropriate for each item. For construction or existing DSS drawings or diagrams that do not comply with the List of Material or Component List requirement, the Program Manager shall consider development of the MCD “A”, “B” or “C” designators for use by those activities that support and maintain the DSS over the entire life cycle. The activity may devise an alternate to the identification system described above, but any alternate procedure must be approved by the Program Manager during the design phase.

It is noted that vendor drawings will not necessarily identify the SOC at the system or piece-part level but the material requirements of this manual shall still be invoked on the vendor.

For all existing DSSs the above requirements only apply to new materials and items which are part of a design change, temporary alteration or modification installed during restricted or overhaul availabilities. For all existing DSSs, sustaining certification during operations, maintenance and repair shall be in accordance with the revision of this manual used for the certification unless otherwise specified by the SCA for the repair or maintenance. However, all activities will have the control processes identified above.

3.3.1 Definition of Material SOC Control Divisions

3.3.1.1 Material Control Division A

Any material in a manned DSS whose single failure would result in DSS loss with DSS personnel on board or death of the DSS personnel. As such, MCD-A is assigned to any component for which back-up protection is not feasible and therefore, even a single failure is unacceptable. This includes components exposed to the pressure differential between ambient sea pressure and DSS internal atmospheric pressure; components of any high pressure (>400 psig) system which are internal to the DSS and which cannot be isolated from the pressure source either by a directly accessible, or a remotely operated, shut-off valve; any piping that penetrates the pressure hull, from the pressure hull to (and including) the inboard flange of the first directly accessible or remotely operated shut-off valve; and all oxygen and hydrogen systems with a design pressure of 100 psig and above. MCD-A is also applied to components within an emergency or back-up system (such as jettison and emergency life support systems and release devices for external appendages) where maximum assurance that the system will operate when needed is essential to preventing a single failure in a primary system from resulting in the death or injury of DSS personnel. MCD-A items include, but are not limited to, pressure hull (plate, forgings, castings, weld filler material, inserts, and penetrations); hard structure; pressure storage tanks and flasks located in

manned spaces; and high pressure or sea connected piping components, including mechanical joints and associated fasteners.

3.3.1.2 Material Control Division B

MCD-B is assigned to any component where failure would require immediate emergency corrective action, the activation of an emergency system, or emergency return to the surface. MCD-B items include, but are not limited to, low pressure (<400 psig) piping and component assemblies in the primary and back-up life support systems; the portion of the electrical power distribution system exposed to sea pressure; instruments and sensors used to monitor external ambient conditions; instruments and sensors used to monitor or control DSS functions; hoses, tethers and umbilicals providing life support or thermal protection; all SOC piping and piping components external to manned spaces, and all other low pressure (<400 psig) SOC piping and piping components within the manned spaces not otherwise classified as MCD-A; mechanical joints and fasteners, not otherwise classified as MCD-A, used on SOC piping systems and piping components.

3.3.1.3 Material Control Division C

MCD-C is assigned to all SOC components not otherwise classified as MCD-A or MCD-B. This includes the emergency electrical power distribution system and also includes other portions of the main electrical power distribution system and electrical components not covered by Section 3.3.1.2 above; and soft goods such as O-rings, gaskets, and seals.

3.3.2 Material Procurement

All SOC material shall be procured in accordance with approved drawings, material/component lists and/or specifications.

3.3.3 Material Marking and Traceability

Material marking and traceability only applies to new material installed. For existing material, refer to the requirements of Section 3.3.6.1.

3.3.3.1 MCD A Material Marking and Traceability

Material marking and identification shall be in the form of unique markings applied to each component or piece of material that allows traceability from the item to the OQE, from manufacturing and receipt inspection through installation.

a. Assemblies will be permanently marked on the exterior of the major component. The marking shall provide traceability to the OQE, for the piece-parts of the assembly

in accordance with each piece's requirements. Disassembly of a component shall not be performed for marking purposes only.

b. Marking shall be located as not to affect the form, fit, or function of the item and, if possible, should be visible following assembly or installation. However, this marking only needs to be maintained up to the time of installation, at which time the marking shall be transferred to the applicable fabrication/installation records.

c. For items which cannot be marked without disassembly, oxygen clean items, welding and brazing filler material, plated parts, or hardened material (where the material finish condition precludes permanent marking), the marking information shall be on a tag or other temporary marking attached to each package, container, can, etc., up to installation.

3.3.3.2 MCD B Material Marking and Traceability

Marking and identification of all material from receipt inspection through fabrication and installation shall be established via tagging or marking. This establishes traceability from the item to the OQE. Marking/Identification may include such items as nomenclature, part number, technical description, National Stock Number (NSN), etc.

3.3.3.3 MCD C Material Marking and Traceability

Documentation for MCD C material need only show visual verification at installation is in compliance with specified requirements such as stock number, design dimensions, surface condition, compliance with assembly or repair instructions, or other characteristics which provide evidence that a deliberate step was taken to install conforming material correctly. There are no unique SOC marking or traceability requirements for MCD C material.

3.3.4 Receipt Inspection

MCD A and B material shall be receipt inspected to ensure conformance with the material specification requirements and any contractually invoked waivers, deviations and engineering changes thereto. Receipt inspections shall be documented. OQE accountability will verify that the documentation is traceable and confirms compliance with the applicable specification requirements. Material awaiting or undergoing receipt inspection shall be physically segregated from accepted or rejected material. Rejected or non-conforming material shall be clearly identified as rejected and segregated. Accepted material will be segregated until installed or identified to a specific end-use.

3.3.4.1 MCD A Receipt Inspection

The minimum OQE requirement for MCD A material is:

a. Chemical and Mechanical testing for all metallic material. Chemical and Mechanical testing for non-metallic materials as required by material specification. If any item is certified Level I, it is considered as meeting the requirement.

b. Records of Nondestructive Testing (NDT) as required by the specification.

c. Records of testing as required by the specification and as noted in Section 3.3.5.

d. Certification (Certificate of Compliance (COC)) that the components comply with the requirements of the procurement document, invoked specifications and drawings. This document asserts that the product material composition and condition are correct, that inspections and test required by contract specification have been accomplished and that the material traceability requirements of this manual have been met. The COC shall contain as a minimum: (a) The contractors, name, address, phone number and date; (b) The issuing agency's purchase order number; (c) Item nomenclature of the purchased item; and (d) Contractor's or authorized personnel's signature. Installation of material on the basis of a COC shall not relieve the installing activity of the responsibility for incorporating material which conforms to the requirements of the drawings and specification. Material not conforming to the requirements of the drawings and specifications will be subject to rejection whether in place or not.

In some cases a Certificate of Test (COT) may be required as evidence that testing was completed. The evidence is embodied in a formal document called a "Certificate of Test". The document, issued by a test laboratory, states that a certain product was tested for certain qualities and shall include: (a) The contractor's name, address, phone number and date; (b) The issuing agency's purchase order number; (c) Item nomenclature of the purchased item; and (d) Contractor's or authorized personnel's signature. The product is identified by description, amount, lot number, etc. Test data are given, along with the conclusion on conformance or non-conformance to specification. The laboratory may be an independent test laboratory, supplier or manufacture's laboratory. The distinguishing characteristic of the COT is that it presents data which are the result of positive, reproducible testing performed to determine the quality of the product. This may also be called a COC or embedded in a COC.

3.3.4.2 MCD B Receipt Inspection

The minimum OQE required for MCD B material is:

a. COC which indicates any of the tests required below have been satisfactorily accomplished and records required by Section 3.3.5.

b. Certification that Hull, Mechanical and Electrical testing was accomplished as required by the specification. The COC must state each contractually invoked test by name and that it was performed satisfactorily. Actual test records are not required.

c. Certification (COC) that the components comply with the requirements of the procurement document, including invoked specifications and drawings.

3.3.4.3 MCD C Receipt Inspection

There are no SOC specific receipt inspection requirements for MCD C material except as noted in Section 3.3.5.

3.3.5 Verification of Completion of Required Testing

Regardless of whether the material or component is MCD A, B or C, if implosion testing, cleanliness testing, toxicity or flammability testing, etc., are required for the item received, the OQE for these tests required by other sections or appendices of this manual shall be verified prior to installation.

3.3.6 Installation Verification

Written procedures shall be developed and implemented which provide assurance that the material meets the requirements of the applicable specifications or drawings.

3.3.6.1 Installation Verification Requirement for MCD A, B and C Material

At the time of assembly or installation of a material into a component, system or subsystem of a DSS, it shall be visually verified as being identical to the material specified on the drawing, material/component list or installation plan. The work procedure or other work control document shall contain an installation record which identifies the material and its location in the DSS. For any previously installed material which is removed and is to be reinstalled, positive control and identification shall be maintained from removal through reinstallation.

3.3.7 Material Transfer

This section addresses material removed from a DSS/operating ship to be installed in a SOC application on another DSS/ship.

3.3.7.1 Material Certification Maintained

Material removed from a DSS/operating ship to be installed in a SOC application on another DSS/ship is acceptable under the following conditions:

a. Re-entry Control (REC) is used to document material removal from the supplying ship. The supplying DSS/ship must be certified, and REC must still be in effect.

b. All outstanding departures, applicable technical variance documentation, the last accomplishment date and category of all applicable Maintenance Requirement Card (MRC) inspections, and all legible component markings shall be documented and supplied to the receiving activity along with a copy of the supplying ship's REC. Positive control and identification shall be maintained from removal through reinstallation. This documentation shall be maintained and filed with the REC package that installs the equipment on the receiving ship. For older DSSs and pre-SSN 688 Class ships, technical variance documentation should be interpreted as any supplemental drawings or data which describe non-standard configurations or modifications.

c. Receiving activity shall conduct material receipt inspection to verify the following conditions:

(1) Received component came from a certified system and REC has been maintained, and that positive control has been maintained since removal from the supplying activity.

(2) Material marking or tagging on hardware matches material marking on supporting software.

(3) Applicable MRC inspections or any other maintenance actions are current for the intended end use.

(4) End use installation is consistent with the previous service parameters such as the design pressure rating, design temperature rating, or system applicability of the component.

d. Receiving activity shall update applicable software to document information and records provided by paragraph 3.3.7.1.b, e.g., DSS or Ship’s Drawing Index (SDI) for drawing revision, date of last MRC periodicity accomplishment, and documentation of outstanding departures into installing DSS or ship's Current Ship's Maintenance Program (CSMP). Material which does not satisfy all requirements of paragraph 3.3.7.1.c shall be acceptable for use under the following conditions:

(1) For material which does not meet the requirements of paragraph 3.3.7.1.c(3), the receiving activity must complete any maintenance due or overdue for the material. Any inspection not performed or other maintenance action not completed must be departed.

(2) For material which does not meet the requirements of paragraph 3.3.7.1.c(4), the material shall be subjected to and satisfy the testing requirements for a new component installed in the receiving DSS or ship, provided the design is consistent with the intended end use.

3.3.7.2 Material Certification Lapsed (DSS/Ship In Inactivation Availability)

a. For SOC material identified prior to the Inactivation Availability start date, to be transferred following commencement of the availability, the following shall be accomplished:

(1) Prior to commencement of system disassembly, material identified for transfer must be included in an identification and transfer system designed for this application. This system must provide a means for tagging components to be transferred to preclude compromise of material control integrity through unauthorized re-entry. NAVSEA considers existing "tag-out" systems as an adequate template for this identification system; however, identification system tags must be durable and clearly discernible from existing "tag-out" system tags.

(2) Identification system tags must include, as a minimum:

(a) The statement that the component is SOC material, and that the component is not to be removed until the tag is uniquely marked by the facility conducting the inactivation.

(b) The DSS/Ship number (e.g., DSRV 1, SSBN 657).

(c) System and item identification (e.g., MIC number, D-4, ASW-1, etc.).

(d) Activity unique identifier (e.g., PHNSY-657-001).

(3) All departures, applicable technical variance documentation, the results of the last maintenance actions (including URO/MRCs if applicable), and all legible component markings shall be documented and supplied to the receiving activity. This documentation shall be maintained and filed with the REC package that installs the equipment on the receiving DSS/ship. For older DSS or pre-SSN 688 Class ships, technical variance documentation should be interpreted as any supplemental drawings or data which describe non-standard configurations or modifications.

b. All work completed on the material/component after removal from the supplying DSS/ship shall be documented and controlled by a REC.

c. For SOC material identified following commencement of the Inactivation Availability, the requirements of Section 3.3.7.3 are in effect.

d. If the SOC material to be transferred is designated for non-SOC end use, and if the removal is to be accomplished subsequent to the Inactivation Availability start date, applicable non-SOC transfer requirements are in effect.

e. Those fasteners removed which connect a transferred item to equipment or components remaining on board, such as valve flange fasteners, shall not be shipped with the item, since to do so needlessly complicates the certification process.

f. The receiving activity shall conduct material receipt inspection to verify the following:

(1) Attached material identification tag and material marking on the material matches the documentation provided from the facility conducting the inactivation.

(2) End use installation is consistent with the previous service parameters such as the design pressure rating, design temperature rating, or system applicability of the component.

g. The receiving activity must complete any maintenance due or overdue for the material. Any inspection not performed or other maintenance action not completed must be departed.

h. The receiving activity must maintain documentation for receipt, inspection, installation and testing of the provided material.

i. The material will be installed using a REC.

3.3.7.3 Material Recertification Required

Material which does not satisfy the requirements of Section 3.3.7.1 or 3.3.7.2 shall require full component certification to all DSS program requirements prior to use. Documentation of this certification shall be traceable from the installing activity's REC.

3.4 Fabrication Process Control

Documentation is required to verify that construction, fabrication, and assembly procedures meet engineering standards necessary to deliver, sustain, and maintain a safe DSS. All written construction, fabrication, and assembly procedures which affect the design performance of the system must be identified and included in the

certification package for technical review. Documentation must include fabrication drawings and specifications, as well as supplementary information which affect the process. Supplementary information of importance includes:

a. Work procedures.

b. Welding procedures.

c. Brazing procedures.

d. Pipe bending procedures.

e. Cleaning procedures.

f. Any other processes, procedures, or instructions required for construction, fabrication, assembly, testing and inspection of the DSS.

Adequacy of these processes must be substantiated by a history of acceptance by a commercial organization or defense agency recognized by the U.S. Government as authoritative (e.g., USN, ABS, Lloyds Register, Det Norske Veritas, etc.) or by documented qualifications and tests.

3.4.1 Work Procedures

All activities responsible for accomplishing work within the SOC shall maintain a program that ensures the adequacy, accuracy and completeness of the work procedures and all changes thereto. Work instructions shall be clearly stated and shall define all work processes including quality standards and tolerance limits that must be followed from the onset of work. Documented work instructions are considered to be the criteria for much of the production, processing and fabrication work. These instructions are the criteria for determination of acceptable workmanship.

3.4.2 Welding Procedures

All welding shall be performed in accordance with defense agency approved written welding procedures. Welding procedures must include requirements for documented welder qualification and criteria for weld joint acceptance. The Program Manager/Sustaining Activity must have available for review welder qualification records, including any destructive/nondestructive test records required for proof-of-welder qualification on the specific material selected. All NDT records, and any required destructive test records of welds shall be made available to the SCA for review. All records shall clearly indicate that each joint has satisfactorily met or exceeded the specification requirements and is verified by the inspector. Any repair involving heat or welding shall be accomplished in accordance with approved written requirements and subjected to the tests and inspections specified for construction.

Both the written welding procedures and the welder's qualification records shall be made available to NAVSEA for review during the survey.

a. The following are examples of satisfactory welding practices:

(1) NAVSEA S9074-AR-GIB-010/278, Requirements for Fabrication Welding and Inspection, and Casting Inspection and Repair for Machinery, Piping, and Pressure Vessels.

(2) NAVSEA T9074-AD-GIB-010/1688, Requirements for Fabrication, Welding, and Inspection of Submarine Structure.

b. The following are typical of satisfactory welder qualification practices:

(1) NAVSEA S9074-AQ-GIB-010/248, Requirements for Welding and Brazing Procedure and Performance Qualification.

(2) ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

3.4.3 Brazing Procedures

For piping systems using brazed joints, all brazing shall be performed in accordance with defense agency approved written brazing procedures which meet or exceed the requirements for brazed joints as described in NAVSEA 0900-LP-001-7000, Fabrication and Inspection of Brazed Piping Systems, or an approved industrial standard. Brazing procedures must include the requirements for documenting Class P-3A, Special Category, Category I brazed joints, brazer/brazing operator and NDT inspector qualifications and the criteria for brazed joint acceptance. All records shall clearly indicate that each joint has met the specification requirements and is signed by the inspector. Any repair to joints involving heat or brazing shall be accomplished in accordance with approved written requirements and subjected to, as a minimum, the tests and inspections specified for construction. When ultrasonic testing or other NDT is required on brazed joints, the brazing procedures, the brazer/brazing operator's and NDT inspector’s qualification records, including any destructive test records required for proof of brazer/brazing operator qualification and test records shall be made available to NAVSEA for review.

3.4.4 Pipe Bending Procedures

For piping systems, all pipe and tube bending shall be performed in accordance with qualified written procedures. Pipe and tube bending procedures shall specify requirements and acceptance criteria for each applicable category of pipe and tube material. Pipe and tube bending procedures shall be qualified for each type of bending

machine. Both the written procedures and qualification results shall be made available to the SCA for review.

MIL-STD-1627, Bending of Pipe or Tube for Ship Piping Systems, is a typical standard for satisfactory pipe and tube bending practices.

3.4.5 Cleaning Procedures

Cleaning of breathing gas systems and components shall be performed in accordance with approved procedures. MIL-STD-1330, Standard Practice for Precision Cleaning and Testing of Shipboard Oxygen, Helium, Helium-Oxygen, Nitrogen, and Hydrogen Systems, and MIL-STD-1622, Cleaning of Shipboard Compressed Air Systems detail qualified practices for the cleaning of breathing gas systems and components. Cleaning procedures used for breathing gas systems or components that differ from the requirements or practices of MIL-STD-1330 or MIL-STD-1622 shall be approved by NAVSEA.

Cleaning procedures shall specify acceptable cleaners, cleaner material compatibility with applicable substrates (metals, rubbers and plastics), cleaning methods and processes, inspection methods, acceptance criteria, and packaging. Records shall be kept of the date that the system or component was cleaned, the cleaner(s) used, the activity performing the cleaning, and all inspection results, and shall be made available for NAVSEA review.

Cleanliness of breathing gas systems shall be maintained during maintenance and repair. Maintaining cleanliness of MIL-STD-1330 applicable systems shall be performed using procedures and personnel meeting the practices and requirements of MIL-STD-1330, or approved industrial standard.

Refer to Appendix G for additional guidance and requirements on breathing gas system cleaning and maintenance of cleanliness.

3.5 Quality Assurance

The DSS Quality Assurance (QA) program shall be a planned, documented, and systematic approach to all the actions necessary to provide adequate confidence that a DSS conforms to technical requirements.

a. In addition to the OQE already addressed in this chapter, the QA program shall contain provisions that result in recorded data related to:

(1) Design and drawing control.

(2) Fabrication and manufacturing control.

(3) Testing and inspection control.

(4) Re-entry control (see Appendix I).

(5) Calibration.

(6) Audits.

b. The vigorous enforcement of a comprehensive QA program for all parts of the system in which failure can result in a hazard to personnel will greatly decrease the chance that substandard workmanship practices, or installation of improper materials will occur and thus degrade the safety of the system. QA provisions are more easily applied during design and construction of a system; however, it is the responsibility of the Program Manager to establish means by which the quality of an existing system may be evaluated. QA programs developed in accordance with MIL-Q-9858 (Quality Program Requirements), ISO 9001 (Model for Quality Assurance in Design, Development, Production, Installation and Servicing) as modified by the Program Manager or DOD directives, or approved industry developed standards are typical of satisfactory practices.

c. Due to the life support nature of DSSs, QA and personnel safety are inseparable. QA considerations are required for all processes that could affect the safety of the DSS personnel. These processes include, for example, initial forming, fabrication, assembly, cleaning, testing, inspection and preparation for delivery of all SOC items. The authority and responsibility of QA personnel in each of these areas shall be clearly delineated. Manufacturing, fabrication, and assembly work conducted within a maintenance facility or industrial facility shall be carefully controlled. Such control shall include a formal review and an engineering technical evaluation of all manufacturing processes and waivers or deviations from specifications. An equally effective control over purchased materials and subcontracted work must be provided.

d. Records are the major form of OQE for documenting conformance to specification requirements. The QA program shall be planned so as to ensure that records are complete and reliable. Careful and frequent review of the record keeping process is essential.

e. The Program Manager shall submit, and retain copies of, information relative to the quality provisions in sufficient depth, detail and organization to permit audit and evaluation by the SCA. Documentation supporting certification shall be legible, accurate and complete.

f. Each document shall be dated and signed and shall indicate, by the signature, that the subject work or procedures meet specification and QA requirements. Such data is vital in the effort to grant and sustain certification. The Program Manager shall make arrangements for the retention, storage and retrieval of the QA documents

required to support the QA program. The Program Manager shall advise the SCA prior to disposing of such records.

3.5.1 Design and Drawing Control

The Program Manager/Sustaining Activity shall establish configuration management and control of the DSS design. The configuration management system used by manufacturing, production, engineering, etc., shall provide control over drawings, specifications, process instructions, production engineering instructions, industrial engineering instructions, and work instructions and all changes thereto, that either implement the design or supplement design drawings to accomplish the manufacture and assembly of the system. Drawings which invoke SOC requirements shall be marked or stamped "SOC".

3.5.2 Fabrication and Manufacturing Control

The Program Manager/Sustaining Activity must be able to demonstrate that the system has been manufactured in accordance with the approved drawings and manufacturing processes. All fabrication records required by specifications and drawings shall be made available, as appropriate, for review by the SCA to support the survey.

The hazards associated with the operating environment and performance requirements of a DSS dictate the acceptance of only the highest quality workmanship. Consequently, the evaluation of the workmanship evident in the finished system is a significant factor in determining the acceptability of the system. Acceptance standards to verify high quality workmanship are available from both defense agency and commercial sources. The Design Agent/Builder/Fleet Maintenance Activity and the Program Manager shall ensure that the specified requirements are met.

3.5.3 Testing and Inspection Control

The Program Manager/Sustaining Activity shall demonstrate that there is an effective test and inspection system in effect. The system shall establish the inspections and tests necessary to substantiate that items within the DSS conform with the specified requirements. The inspection system shall incorporate clear, complete, and current instructions for inspection and shall include criteria for acceptance and rejection. Records of all inspections and tests shall be maintained and shall indicate the deficiencies found and the corrective action taken. All test and inspection documents shall clearly show the following as a minimum:

a. The testing activity;

b. The items, subsystems, and systems tested;

c. The test requirements;

d. That test results meet or exceed requirements;

e. That departures from test requirements are justified, documented and approved by the Cognizant Technical Authority; and

f. The dated signatures of individuals responsible for testing and final evaluation of test data.

g. Appendices may contain additional OQE requirements.

Inspection control processes shall ensure that the latest applicable drawings, specifications and process controls, with all authorized changes incorporated, were used for fabrication, inspection and testing. The inspection system shall describe the training and qualification of inspectors and shall include demonstration of competence in techniques such as radiographic, ultrasonic, dye penetrant and magnetic particle inspection, if required. Test documents and data that fail to meet test criteria, that are incomplete or that are not technically evaluated, but are signed off as satisfactory will be rejected by the SCA.

3.5.4 Calibration

The inspection system shall provide for calibration of inspection equipment. The calibration system shall be established, documented and available for review. A system described in ISO 10012-1 (Quality Assurance Requirements for Measuring Equipment), or ANSI/NCSL Z540-1 (Calibration Laboratories and Measuring and Test Equipment - General Requirements) is an example of a satisfactory method.

3.5.5 Audits

The QA program shall provide for a system of periodic internal audits, deficiency resolution and management reviews to determine the status and adequacy of the QA program.

3.6 Test Performance

The Program Manager shall develop and implement a written test program. It shall consist of a comprehensive and integrated series of tests which fully demonstrate the adequacy of all systems and equipment within the DSS. The test program should consist of and meet the intent of the following elements:

a. A test procedure index which lists all the individual test procedures with an identification number, title, latest revision number, and date of issue. Those tests that are required to satisfy SOC items should be uniquely identified and shall be annotated

on the test procedure index. The Program Manager shall provide a test index for items within the SOC to the SCA for review. The SCA will advise the Program Manager which test procedures require SCA review and Program Manager approval.

b. Test procedures should include both the test procedure and the data to be collected. The Program Manager with SCA concurrence will determine which test results require NAVSEA review and approval.

c. Tests required for certification are grouped into the three categories of Development Tests, Quality Assurance Tests, and System Operation, Integration and Proof Tests.

3.6.1 Development Tests

These tests are required to verify the design basis of the DSS and any subsequent modifications within the SOC. The following shall be demonstrated by such tests:

a. The performance of materials,

b. mechanical designs and configurations, and

c. systems which are unique or untried in a similar environment.

Guidelines for categorization of materials and components within the SOC are provided in Appendix A.

Tests used to demonstrate the design basis of the DSS need not necessarily be performed on the actual DSS. In some instances, testing of a duplicate component may be appropriate. A further description of developmental material and structural testing requirements can be found in Appendix B.

3.6.2 Quality Assurance Tests

These tests are performed to demonstrate that the components and materials used in the fabrication, repair or modification of the DSS do, in fact, conform to design requirements. They include, but are not limited to, such items as NDT of materials and welds, fabrication tolerance measurements, calibration tests, breathing gas purity tests, and vendor's acceptance tests.

3.6.3 System Operation, Integration and Proof Tests

These tests are intended to confirm the adequacy of design, the operational characteristics, the operational procedures to be used with the DSS, and the integration of the subsystems.

3.6.3.1 Proof, Builder's Pre-Trial or Pre-Sea Trial Tests

Proof test procedures shall be developed by the Design Agent and approved by the Program Manager. As each step in the test procedure is satisfactorily completed, the person performing or witnessing the test shall immediately sign and date that step on the test form. If the test requires that a particular parameter be within a specified range, the range shall be specified and the actual value shall be recorded. A test schedule will be provided to the SCA by the Program Manager to allow the SCA to monitor critical testing.

3.6.3.2 Structural Testing

When applicable, the Design Agent/Builder shall submit to NAVSEA for approval a strain gage plan including, as a minimum, location and type of strain gages. The final test report must include a comparison between calculated stress values and those obtained by strain gages, including specified maximum allowable stress.

3.6.3.3 Fluid System Testing

All fluid systems and components, to include liquid and gas, within the SOC shall be tested to demonstrate satisfactory fabrication, assembly and operation.

All fluid systems internally and/or externally pressurized shall be pressure tested to verify strength and porosity of forged, cast, extruded, welded and brazed material. Additionally, all fluid systems internally and/or externally pressurized shall be pressure tested to verify the tightness of mechanical joints and valve seats. Furthermore, when applicable, gas systems shall be pressure drop tested. Refer to Appendix J for additional guidance and requirements on pressure testing of fluid systems and components.

All breathing gas systems shall be off-gas tested to verify the absence of volatile toxic compounds and purity of the breathing gas prior to manned use. Refer to Appendices F and G for additional guidance and requirements on off-gas testing of breathing gas systems. Off-gas testing cannot be used to verify the cleanliness of breathing gas systems.

All fluid systems and components shall be operationally tested to demonstrate that the system meets all top level performance requirements prior to certification. All system operational tests shall record sufficient data, with applicable acceptance criteria, to demonstrate satisfactory operation.

a. Satisfactory operation of all pressure-relief or safety cutout devices shall be verified prior to system operational testing.

b. All life support systems, including habitability and breathing gas shall be operationally tested prior to manned use.

c. Systems that effect vehicle attitude, depth or recovery shall be operationally tested to the maximum extent prior to submerged operation.

d. Where operational testing could damage the DSS, such as operation of a fire fighting system, or where a single test would not verify repeatable performance, such as operation of explosive drop weight systems, alternative tests and/or practices shall be developed.

3.6.3.4 Cleanliness Testing

All life support, and breathing gas or other systems, for which cleanliness is considered critical to DSS personnel or system operation, shall be cleaned in accordance with approved procedures. Satisfactory completion of the cleaning procedure will be based upon test verification of cleanliness and trace contaminant levels.

An analysis of the DSS atmosphere must be taken in accordance with the requirements of Appendices F and G.

3.6.3.5 Electrical Testing

The Program Manager shall submit test procedures designed to demonstrate the adequacy of electrical continuity and Insulation Resistance (IR) of all electrical circuits which are in the SOC.

a. These procedures shall specify not only the pass/fail criteria for the test, but also such test conditions as water temperature, pressure, and duration.

b. All types of electrical cables, equipment, and devices within the SOC shall be qualified by type by subjecting to a dielectric strength test at 60 Hertz for one minute. The dielectric test voltage shall be the test voltage of "twice-rated" plus 1000 volts. The cable dielectric tests shall be performed between all conductors and the sheath and also between individual conductors. This is a "go, no go" criteria test. Subsequent dielectric strength testing shall be conducted at 75% of the voltage applied the first time. Dielectric strength tests shall always be followed by an IR test.

c. All subsequent IR testing shall be with DC voltage. The DC voltage shall not be less than 500 volts held for one minute for electrical cables, equipment, or devices unless it can be shown that such a test would be detrimental to the equipment (e.g., pyrotechnic jettisoning devices). IR measurements of all safety circuits, excluding the actuating device, shall be made part of the pre-dive check-off list. A log of periodic IR readings for all electrical systems and circuits is a valuable tool in planning

maintenance and repair schedules. Humidity, contamination of insulation materials, accumulation of foreign matter on insulating surfaces, and the length of cables have a bearing on IR values. Therefore, the change in IR values is of major significance. After being idle for a period of time, equipment and cables may exhibit lower than normal readings, but after a time in operation, the readings may return to normal indicating moisture caused by high humidity. However, a steady gradual decline in IR values is an indication of insulation contamination or collection of foreign matter on the insulating surfaces. Ten megohms is acceptable for each circuit when newly installed. One megohm is acceptable system IR. If the system IR drops an order of magnitude and the fault cannot be removed, an operational abort should be considered.

d. A dive abort is mandatory at a system IR value of 50K ohms or less, unless the system can be safely isolated.

3.6.3.6 Inclination Testing

The stability of the DSS shall be demonstrated both surfaced and submerged for normal conditions. Stability in emergency conditions may be calculated or extrapolated.

3.6.3.7 Access to Vital Equipment

Access to vital equipment is defined as the ability to reach, read, and/or operate components and equipment identified as vital to the recovery and emergency operation of the DSS. Appendix L provides an example of a shipcheck test form required to be conducted to ensure that components and equipment vital for recovery and emergency operation are readily accessible for operation.

3.7 Operational Demonstration and Trials Stage (Builder's Trials or Sea Trials)

The sequence of events and the interrelated certification actions accomplished by the activities involved, leading to initial or post overhaul trials and initial certification or reinstatement of certification are summarized as follows:

a. The Sustaining Activity and/or Program Manager conducts an internal survey.

b. The Sustaining Activity and/or Program Manager requests an SCA on-site survey.

c. The SCA conducts an on-site certification survey.

d. The Sustaining Activity reports to NAVSEA certifying that no deficiencies exist which could affect personnel safety or material safety of the system in support of trials. The report shall contain the status of all outstanding certification survey cards.

e. A statement detailing the trial schedule shall be submitted to NAVSEA. Also included shall be a description of general environmental considerations concerning safety (e.g., sea state limits, visibility limits, DSS handling capabilities, limits on diving under overhangs, cables, caves, etc.). The User Activity submits a trials agenda to the Sustaining Activity and to NAVSEA for review and approval. Where the User Activity and Sustaining Activity share the same responsibilities, the Sustaining Activity submits the sea trial agenda to NAVSEA.

f. The User Activity/Sustaining Activity conducts the trials. Trials shall be conducted to test and check out all systems, components, and portable support equipment. The certification operational demonstration may be conducted in conjunction with other program requirements (i.e., operational evaluation, trials, factory/plant acceptance test, etc.). Satisfactory completion of trials is mandatory. The tests listed below represent examples of tests required to be conducted during trials:

(1) Normal pre-dive maintenance checks.

(2) Normal and emergency life support system test.

(3) Sound-powered phone system (topside pilot communications system) test.

(4) Test radio transceiver and inspect antenna.

(5) Check operation of battery breakers and bus tie.

(6) Inspect all internal power distribution panels.

(7) Check operation of ground and leak detector systems.

(8) Test navigation system.

(9) Check hatch operations.

(10) Check operation of all meters and gauges.

(11) Test all alarms.

(12) Test Underwater Telephone (UQC) and Transponder Interrogator Pinger Echo-Sounder (TIPE) option.

(13) Test lighting circuits (internal and external).

(14) Test all sonars.

(15) Test manipulator(s).

(16) Test emergency identification light.

(17) Check for leaks around all penetrators, viewports, and hatches.

(18) Inspect or test all emergency/damage control equipment (as applicable).

(19) Test atmosphere monitoring/control equipment.

(20) Charge main batteries and safety/emergency batteries.

(21) Test variable ballast system.

(22) Check mechanical and electrical emergency release mechanisms.

(23) Test camera and strobe system(s).

(24) Test main ballast tank blow and vent system.

(25) Monitor batteries with voltage detector and computer.

(26) Test depth indicating system.

(27) Conduct Post-Dive Checklists.

g. The User Activity/Sustaining Activity reports completion of the certification dive to NAVSEA, noting any deficiencies within the SOC. Should a material deficiency to an item within the SOC occur during trials that is not correctable by routine repairs, or results in a dive being aborted, a report to NAVSEA is required in order that reassessment of material condition may be made. NAVSEA will then assess the material adequacy of the vehicle to continue trials and reply if further action is required.

h. The Sustaining Activity reports to NAVSEA correction or resolution of deficiencies noted during the certification dive and the completion of any outstanding Category IB survey items, and requests certification be granted.

i. The Sustaining Activity forwards the data package for the certification operational demonstration to NAVSEA for review and acceptance. This package must include the completed pre-dive and post-dive check-off procedures, the on-board dive log, and REC documentation for deficiency correction. All OPs/EPs not demonstrated during trials shall be performed prior to final certification.

j. After review and acceptance of the submitted data package the SCA issues the formal Letter of Certification to the Sustaining Activity.

3.7.1 Certification Dive

A DSS shall be subjected to a test dive to the maximum depth at which it is to be certified or recertified to operate. An unmanned dive prior to the manned dive should be considered when developing the overall program plan. The test dive area shall not be deeper than 110 percent of the planned DSS dive depth. Before proceeding to maximum depth, the DSS shall be maintained at a depth below the near surface thermocline for a shallow depth inspection. If the DSS is not designed to be maintained at the depth described above, an alternate method of achieving shallow depth inspection shall be determined. All joints and penetrations accessible from within the DSS shall be inspected visually at this depth. All components subjected to submergence pressure and whose operation is required for safe operation of the DSS must be operationally tested; accessible welded and mechanical joints and valves shall be inspected and the inspection results logged. The submergence depth shall then be increased in increments until the maximum operating depth is reached. At each appropriate increment the DSS shall achieve neutral buoyancy while appropriate inspections are conducted. Unsatisfactory operation of a subsystem or component may be cause for failure of the test. The test dive may be a single dive, as described, or a series of dives to accomplish the same purpose. A log of carbon dioxide and oxygen concentration, temperature, ground resistance readings, and any other parameters as directed by the approved test procedure shall also be filled out and maintained. Readings shall be taken at least once every 30 minutes to analyze for trends and to demonstrate safe operation and subsequent acceptance of the system. A schedule of the test dive shall be provided by the Program Manager to the SCA. An SCA representative shall participate in or witness the test dive.

3.7.2 Emergency Surfacing

The operation of the emergency deballasting or jettisoning systems shall be demonstrated at sea where practicable. Where such operation may damage the DSS, a simulated emergency deballasting or jettisoning test may be performed. Such a test simulation procedure shall be submitted to NAVSEA for approval prior to accomplishment of the test. A means of releasing external appendages which could become entangled (e.g., boom-mounted light and camera arrays, anchors, sample baskets, manipulators, etc.) shall be provided or means taken to prevent (or minimize) the possibility of entanglement. Since a function of these devices is to be releasable without endangering the DSS in the event they become entangled, testing the systems for satisfactory operations shall be performed under adverse trim conditions and, where practicable, during an "at-sea" demonstration.

3.7.3 Test Dive Deficiencies

All deficiencies noted within the SOC during the test dive shall be recorded and reported to NAVSEA. The Program Manager, with SCA concurrence, will determine

which deficiencies must be corrected prior to manned use. These deficiencies shall be satisfactorily resolved prior to continuation of manned testing or operations.

3.7.4 Manned Use of One Atmosphere DSSs in Pursuit of Certification (or Reinstatement of Certification)

During periods when certification or reinstatement of certification is being pursued for a DSS, testing may be required which necessitates manned use prior to sea trials, operational demonstration, or other event requiring formal SCA approval for manned use. This provides the requirements to authorize conducting those tests/dives.

a. For manned dives/testing with the system wet (tethered and in a pool, tethered to a certified lift system in port, or in a certified captured lift system in port or at sea), the following items must be assessed for impact on the DSS operator's safety during the test/dive. The assessment must be provided to the SCA, for information only, at least 24 hours prior to conducting the evolution. The activity accomplishing the manned testing does this assessment. The approval for the manned testing is provided by the organization immediately above the User Activity in the chain of command.

(1) Provide an impact assessment for any open Category IA certification survey cards.

(2) Identify any outstanding deficiencies that may impact testing/dives.

(3) Identify all open RECs and provide an evaluation of the impact of the RECs on planned testing/dives.

(4) Ensure life support systems and communication systems tests have been satisfactorily completed and are functioning properly.

(5) Ensure the results of the closed boat atmosphere analysis (bomb sample) are satisfactory.

(6) Ensure OPs/EPs that will be used during the test/dive, including pre-dive and post-dive procedures, have been updated to reflect new installations and system modifications.

(7) Ensure preventive maintenance procedures that will be used prior to and during the test/dive, have been updated to reflect new installations and system modifications.

(8) Ensure the safety analysis of new installations or modified systems that will be operated or tested during the dive has been evaluated by NAVSEA and that there are no hazards that impact planned tests/dives.

(9) Ensure electrical system testing (e.g., continuity, IR, and ground checks) has been accomplished to the extent necessary to ensure electrical hazards do not exist to the operators.

b. For manned testing with the system dry, items (1) through (9) above should be assessed for their impact on the DSS operator's safety during the test.

c. All other manned testing for one atmosphere systems and all manned testing of other than one atmosphere systems requires SCA authorization. One atmosphere manned testing of other than one atmosphere systems will follow the preceding requirements.

3.8 Operating and Emergency Procedures

Written procedures shall be provided for NAVSEA approval which cover normal and emergency operations. The Program Manager shall develop normal and emergency operating procedures. These procedures shall be supplemented as necessary by diagrams, system installation/alignment procedures, system shutdown procedures, pre-operation and post-operation procedures, and other such procedures as may relate to normal and emergency operations. All OPs/EPs and their changes must be validated by the Sustaining Activity and shall be approved in writing by the Program Manager with SCA concurrence. The SCA shall require that this approval be granted prior to certification. Compliance with approved OPs/EPs is a requirement for sustaining certification. Written procedures shall be prepared to ensure the following:

a. That the normal operation of the diving system is within the safe operating conditions for which certification is granted;

b. That there are adequate procedures to cope with emergencies, including identification of mandatory abort conditions;

c. That there are checklists of prerequisites for various major evolutions (e.g., installation, pre-dive and post-dive procedures, repairs and maintenance, and periodic inspections);

d. That sufficient operating stations are identified and that the duties of operating personnel are adequately defined; and

e. That up-to-date information is available for operator training and that it is consistent with safe operation of the diving system.

The adequacy of the normal and emergency procedures developed or updated for operation of the DSS shall be demonstrated prior to certification or reinstatement of certification.

3.8.1 Operating Manual

An operating manual(s) shall be provided for NAVSEA approval that describes all equipment and all phases of system operation. The following information, as a minimum, shall be included:

a. System Description. This section shall identify and describe the purpose and functional operation of all systems and subsystems.

b. Component Description. This section shall include sufficient design information to identify and describe all major system components and their functions.

c. Instrumentation and Controls. This section shall discuss the control philosophy used in the system design and provide a detailed description of the controls and instrumentation used.

d. Operating Procedures. This section shall identify all normal system operations and evolutions which involve personnel. Detailed, step-by-step procedures for these normal operations and evolutions shall be provided. The procedures shall contain a properly approved checklist which will be used to verify proper system alignment under all normal operating conditions. Operations checklists shall identify the support equipment required for major operational evolutions, such as pre-dive preparations, diving, or post-dive servicing. A condition for certification of the DSS will be that the support equipment is operable and performing properly. Checklists shall be signed by an appropriately responsible designated person.

e. Emergency Procedures. This section shall identify conditions requiring emergency operation and provide procedures to be followed in the event of their occurrence. Emergency operation is defined as operation under conditions of system malfunction or failure such as loss of power, component failure, physical damage or fire. Detailed, step-by-step immediate actions for dealing with these emergencies shall be provided.

f. System Limitations, Precautions, Set-Points. This section shall clearly identify all system operational limitations. This section shall also state all precautions to be taken during normal operation to preclude potentially unsafe conditions. A list of system operational profile set-points which represent the normal operation of the system shall be included. (See Appendix E for life support system limits.)

g. Handling Operations. This section shall provide handling procedures to cover any intended handling of the diving system such as during the air/sea interface penetration and the mating of pressure vessels. Where appropriate, the procedures shall include details and precautions for handling, lifting, and securing of the system, as well as system breakdown and reassembly for transportation. Normal and emergency operating procedures must be correlated with the handling procedures to demonstrate

that they are satisfactory. For highly complex systems, a separate operating manual for system handling may be necessary.

3.9 Maintenance Procedures

Sustaining certification is predicated on maintaining the system in the "as-certified" condition. The Program Manager shall develop formal maintenance procedures for all systems, subsystems and components within the SOC. These procedures will be considered in the certification process insofar as they relate to safe operation of the system. The Program Manager shall ensure that all maintenance and monitoring procedures developed, updated and maintained as required by this manual are coordinated with the Planned Maintenance System (PMS), if applicable, to avoid redundancy or conflict. All maintenance procedures, MRCs and their changes shall be approved by the Program Manager with SCA concurrence. The maintenance program shall include, as a minimum, the following information:

a. Preventive maintenance instructions including calibration and alignment of instrumentation and servicing of other equipment as appropriate for the DSS.

b. REC procedures that cover definition of the boundary entered, work to be accomplished, post repair inspection and testing required to ensure proper integrity and operation of all systems and equipment. Appendix I provides the intent of and an example of a REC procedure, as well as requirements for REC exception.

The Program Manager or Sustaining Activity shall provide instructions for conducting periodic inspections and tests to ensure continued safe operation of the DSS. The instructions shall include the scope of the inspections and tests and shall provide pass/fail criteria. These periodic inspections and tests shall be a condition for sustaining certification. Normal inspections should be planned to coincide with planned overhauls or maintenance upkeep periods.

An operation and maintenance technical manual, including trouble-shooting instructions shall be submitted to the Program Manager for review and approval.

3.9.1 Maintenance Requirement Card

MRCs are developed to provide minimum maintenance requirements for specific areas of interest within the DSS to determine if the conditions of these areas are suitable for continued operations. MRCs provide detailed procedures for performing maintenance requirements and describe who, what, how, and with what resources a specific requirement is to be accomplished. MRCs are prepared and administered using Chapter 3 of OPNAVINST 4790.4, Ship's Maintenance and Material Management (3-M) Manual, as a guideline.

The maintenance procedures for all equipment within the SOC will be prefaced with a note to alert all individuals conducting planned maintenance that they are working on DSS SOC equipment and must strictly follow approved procedures. The PM will ensure the use of one of the two notes below, as appropriate; or may, with SCA concurrence, develop and use equivalent notes. It is critically important that individuals performing planned maintenance be made aware that, even though a particular maintenance procedure does not require REC, any repair or replacement of SOC components necessary to correct a deficient condition identified during that maintenance may require REC.

a. "This maintenance involves equipment within the DSS SOC as defined by the SOC Notebook or applicable document. Performance of this maintenance requires that REC be utilized."

b. "This maintenance involves equipment within the DSS SOC as defined by the SOC Notebook or applicable document. Performance of this maintenance does not require REC. However, if repair or replacement of any component is necessary, compliance with system certification requirements must be documented."

3.9.2 SOC Planned Maintenance Documentation

To validate the performance of maintenance requirements, it is necessary to provide documentation that the maintenance is being accomplished at the required periodicities from survey to survey. The SOC planned maintenance can be accomplished under two individual categories, SOC-REC Required (SOC-REC) and SOC-No REC Required (SOC-NRR). Based on the maintenance task complexity, system boundary and material control requirements, the determination for SOC-REC implementation will be made by the Program Manager. The SCA will review maintenance accomplishment documentation during certification and sustaining surveys. Violation of SOC-REC requirements could lead to suspension of certification.

a. SOC-REC planned maintenance accomplished within the SOC shall be documented and audited using the REC as OQE.

b. SOC-NRR planned maintenance accomplished within the SOC, while not controlled by REC, may require documentation to record that the required inspections, tests, etc., have been accomplished satisfactorily as scheduled. The Sustaining Activity shall, depending on the frequency and complexity of the maintenance action, determine the methodology of documenting the accomplishment and completion of SOC PMS in a format suitable for audit. The maintenance requirements shall identify that documentation is required.

c. The PMS schedule shall be maintained in accordance with maintenance procedure requirements. The completed schedules shall be retained and available for SCA review during surveys.

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Chapter 4
On-Site Certification Survey

4.1 Introduction

The purpose of surveys is to verify that the DSS was fabricated, maintained, repaired and operated as required. The initial certification survey verifies that the DSS was fabricated in accordance with the approved design, that the OQE correctly reflects the "as-built" system, and that there is maximum reasonable assurance that the material and procedural adequacy of the system is at a level that will allow completion of the certification process. The sustaining certification survey verifies that the DSS has been and is being operated and maintained in the as-certified condition in accordance with the Letter of Certification.

4.1.1 Initial Certification Survey

Upon completion of DSS fabrication and testing, and technical review of the OQE required by the CSP, an on-site survey of the DSS shall be conducted by the SCA or his designated representative. The initial certification survey shall be officially requested by the Program Manager.

4.1.2 Sustaining Certification Survey

Subsequent to the initial certification, follow-up certification surveys shall be performed periodically as specified in the Letter of Certification, by the SCA or his designated representative, as a condition of sustaining or continuing certification.

4.1.2.1 Sustaining Certification Survey Periodicity

The periodicity of the SCA sustaining surveys will be negotiated between the Program Manager and the SCA, and will be based upon the results of the last survey performed by both the Sustaining Activity and the SCA, as well as other oversight performed and other performance indicators available. DSS operating schedules will be considered when scheduling the periodic surveys. Once a periodic survey is scheduled, any change to the schedule requires NAVSEA concurrence.

If the SCA survey periodicity is 15 months or greater, the Sustaining Activity shall perform at least two internal surveys between the SCA surveys, not to exceed a 12 month periodicity. The results of the surveys are to be forwarded to NAVSEA for review.

4.1.3 Reinstatement of Certification Survey

A reinstatement of certification survey may be required at the discretion of the SCA to verify the satisfactory resolution of the events or findings that caused a suspension of certification. If the SCA determines that a reinstatement of certification survey is necessary, the requirements of the CSP used for initial certification shall apply.

The follow-up survey shall use a CSP tailored by the Sustaining Activity and approved by NAVSEA to ensure that all SOC work and all operations performed since the last survey receive an adequate review. When the DSS does not have an approved CSP developed in accordance with Appendix K, and there is no SOC work, or the magnitude of SOC work accomplished does not warrant the use of the CSP based on Appendix K, then the SCA may elect to utilize Figure 4-2 or Figure H-1 as applicable to conduct the survey.

4.2 Preparation For Survey

Prior to the SCA on-site survey, an internal survey shall be conducted to evaluate compliance with certification requirements. The internal surveys will use and address the elements of the approved CSP. The internal survey for initial certification, or reinstatement of certification following an availability, is performed by the industrial facility and the internal surveys to sustain certification are conducted by the Sustaining Activity.

During surveys, the supporting OQE discussed throughout this manual as defined in the CSP should be organized and immediately available on-site to support the survey.

4.2.1 Scheduling of SCA Surveys

To ensure an activity is ready to support a survey, the following prerequisites for scheduling the survey have been established. These prerequisites will be used to determine if work has progressed to the point that an SCA certification survey is justified. Any request to schedule, or change the schedule of a survey must be accompanied by the status of each requisite item. Requests for deviation from these prerequisites will be handled on a case basis and will be specifically approved by the SCA.

4.2.1.1 Work Control Program

As a minimum for the initial certification survey, 85 percent of SOC items under the work control program (e.g., RECs) must be complete. Complete work means all work, testing, and recertification associated with the document has been completed. A Readiness For SCA Survey Status Report, using Figure 4-1 as an example, will be submitted with all requests to schedule, or change the schedule of, the SCA Survey. It is to be updated weekly.

NOTE: If a sustaining survey coincides with a short availability such as a Technical Availability (TAV) or Restricted Availability (RAV) that is 30 days or less, 60 percent of SOC items for the availability under the work control program must be complete. For longer availabilities such as TAVs, RAVs or overhauls that are greater than 30 days in length, the 85 percent rule applies. If a sustaining survey does not coincide with an availability, no completion requirement exists, but status of SOC items including the extent of work done since the last survey shall be submitted to the SCA.

4.2.1.2 Maintenance Requirement Status

All SOC maintenance requirements must be current and, if requested, reports submitted to the SCA prior to the start of the survey. All maintenance logs must reflect the current status of maintenance actions. Deferred maintenance requirements must be appropriately approved and documented in accordance with existing documents.

4.2.1.3 Testing Procedure Status

Test forms/procedures must be completed prior to the start of the SCA survey in accordance with the following requirements (for initial certification or systems completing an availability):

a. At least 90 percent of the SOC portion of all strength and tightness tests shall be completed.

b. All SOC operational tests and inspections which are possible to complete shall be complete.

NOTE: At-sea and manned testing is excluded from the above requirements.

4.2.1.4 Departure Status

Provide a list of all open (unapproved or conditionally approved) DFSs (deviations and waivers).

NOTE: During overhauls or extended availabilities, this may require the Sustaining Activity to obtain input from other activities to ensure a complete status is reported.

4.2.1.5 Certification Survey Plan

The Sustaining Activity must obtain NAVSEA approval of an updated CSP at least two weeks prior to the SCA survey. The CSP shall be used for the internal survey.

4.2.1.6 Internal Survey Status

a. Overhaul/New Construction - The activity’s internal survey must be completed not more than 30 days prior to the SCA survey and the results of the internal survey must be submitted to NAVSEA at least 10 working days prior to the start of the SCA survey. If time constraints do not permit submittal of the internal survey report within 10 working days of the SCA survey, the SCA shall be informed by the Program Manager to ensure that an adequate review of the internal survey can be accomplished by the SCA.

b. Others - The Sustaining Activity’s internal survey must be completed in time for the results to be submitted to NAVSEA at least two working days prior to the start of the SCA survey.

c. An updated copy of the activity's internal survey reflecting actions taken as a result of the findings shall be made available to the SCA at the time of the SCA survey.

READINESS FOR SCA SURVEY STATUS REPORT								
	1	2	3	4	5	6	7	8
DATE OF REPORT								
1. SOC Items complete (percent) (Min-85/60 percent)								
2. Periodic Maintenance Status (Min-Current)								
3. Test Form Status - (Init Cert & Recert only) a. S & T (Min-90 percent)								
b. Op/Insp (All Possible)								
4. Departures - Attach a list of open departures with departure status indicated								
5. CSP - (date submitted/approved)								
6. Internal Survey Status (Date for Completion/Date submitted)								

NOTES:_____

_____

_____

_____ _____

Signature Date

Figure 4-1

4.2.1.7 Personnel

Key personnel must be present (OIC, Engineering Officer (ENG), etc.) to support the survey. It is also essential that qualified personnel knowledgeable in all aspects of the DSS (operation, design, testing, QA, maintenance, etc.) be available and ready to assist the survey team.

4.3 Survey Team Personnel

The SCA will assemble a survey team and perform the on-site survey of the DSS. The type and complexity of the DSS and the extent of work performed within the certification boundary will determine the size and makeup of the survey team. Typically, the areas of expertise of the survey team will include QA, structural, mechanical, piping and life support, electrical, and ocean and marine engineering. Specialists in hydrodynamics and hydraulics will be included on a case basis.

4.4 Certification Survey Cards

Deficiencies noted during the survey and recommended corrective action shall be documented in the form of certification survey cards. Survey cards shall be cross-referenced to line items in the CSP and classified by the SCA as follows:

a. Category IA - Findings of such importance that manned use of the system will not be authorized and certification will be withheld until the deficiencies are satisfactorily resolved. These deficiencies must be satisfactorily resolved and the resolutions accepted by the Program Manager and SCA to ensure the material condition of the DSS is verified as satisfactory prior to manned use.

b. Category IB - Findings which will allow manned use of the system for conduct of specific controlled evolutions, but will not allow issuance of the Letter of Certification until the deficiencies are satisfactorily resolved or required actions taken. These findings must be satisfactorily resolved and the resolutions accepted by the Program Manager and SCA to ensure the material condition of the system is verified as satisfactory for use prior to the issuance of the Letter of Certification.

c. Category IC - Findings of such importance that satisfactory resolution must be accomplished prior to a specific date or event specified on the survey card to sustain certification. These items must be satisfactorily resolved and the resolutions accepted by NAVSEA, or be granted an extension approval from the SCA prior to the date or event specified in order to sustain certification.

d. Category II - Findings which, while not mandatory for resolution to obtain or maintain certification, identify systemic weaknesses in the DSS program. These deficiencies should be resolved in a timely manner.

e. Category III - Items audited and found acceptable.

At the conclusion of the survey, a critique will be held. The survey team leader will review and discuss survey cards and recommended corrective action with the activity. The survey team leader may, as a courtesy, leave draft copies of the survey cards. The draft copies are for discussion purposes only and are subject to change prior to issue of the official survey report.

Upon completion of the survey, the SCA will debrief the results of the survey team's evaluation of the system with the Program Manager. The survey report will then be finalized and forwarded to the Program Manager for action.

When action identified by a specific card has been completed, a brief summary shall be written on the card and the card signed by a senior representative of the activity responsible for the corrective action. Cards must then be returned to the SCA, via the Program Manager, for acceptance. Supporting OQE (e.g., REC forms, test memos, NDT records, calibration data, etc.), should be referenced on the card and the applicable portions submitted with the card to the SCA. For corrective action to be considered satisfactory and the card cleared, it must be signed by the SCA and the Program Manager's representative. The Program Manager will be responsible for management and tracking of Category IA, IB, and IC survey items. The SCA will be responsible for management and tracking of Category II survey items. Each activity is responsible for reporting current status of corrective action on all outstanding Category IC and Category II survey items to the SCA via the Program Manager to allow updating of the quarterly report.

A quarterly report of the outstanding survey items will be provided by the SCA to the each activity and the Program Manager for review and validation.

4.5 Survey Guidelines

Deficiencies that are known to the Program Manager or others must be brought to the attention of the survey team and discussed. Certification survey cards should not be viewed as representative of either system or personal failure, but rather the findings of conscientious specialists in the field of DSSs who are responsible for reviewing the material and procedural adequacy of the system, to ensure the safety of the occupants.

4.6 Operational Demonstration

Upon satisfactory resolution of all Category IA discrepancies and with the concurrence of the SCA, a certification operational demonstration as specified in Section 3.7 shall be conducted.

DEEP SUBMERGENCE SYSTEM (DSS) NAVSEA
SUSTAINING SURVEY PLAN
(Tailor to Suit DSS)

DSS:_____ Date/Location of Survey: _____

Team Leader(TL)/(ATL): _____

Date/Location of Last Survey: _____

☐ Previous Survey Data:

Certification Letter:_____

a. Ensure that the certification letter is available.
b. Is certification of the system current?
c. Was certification extended beyond original due date? Certification extension letter:_____
d. Are all previous survey issues resolved?
e. Are there any outstanding departures?

COMMENTS: _____
_____

☐ 1. Review a sample of Dive Logs from the last survey to present, which includes Dive No. _____ through _____ to assure completeness with emphasis on the following:

a. Are pre-dive and post-dive check-off sheets complete, signed-off, and are all required repairs identified?
b. Are emergency recovery systems in proper order and are recorded readings within specifications?
c. Were all discrepancies within the SOC satisfactorily resolved prior to the next dive?
d. Are all life support, electrical and other critical readings satisfactory? Are readings being taken within prescribed periods?
e. Is the system being operated within the limits stated in the certification letter?
f. Were any dives conducted with open RECs?

COMMENTS: _____
_____

Figure 4-2

☐ 1.1 Compare the Dive Log, REC Log and Equipment Deficiency List (EDL) to ensure that deficiencies are corrected and all RECs were closed prior to dive.

☐ 1.2 Verify that any operations outside SOC limitations or casualties/damage affecting SOC were reported to NAVSEA by CASREP, immediate message, etc.

☐ 2. Review a sample of material/component accountability for SOC items reworked or replaced subsequent to the last survey.

☐ 2.1 Review a sample of maintenance documentation for SOC items (i.e., MRCs, RECs) from the last survey to present.

a. Accountability by REC No. _____ through _____

NOTE: If any configuration changes (excluding departures and Temp Mods) have been accomplished, use the applicable section of the CSP. This is accomplished by listing the specific sections which need to be covered. The use of the CSP sections will provide more visibility to the items covered.

☐ 2.2 REC review guidelines:

a. Proper approvals, sign-offs, and adequate reviews.
b. Was the OQE satisfactory for the new material, used/old material being reused?
c. Correct references/reference revisions.
d. Work conforms to drawing requirements.
e. Were required inspections conducted? Was proper torque applied? Was fabrication control adequate?
f. Was testing in accordance with requirements? Did the test results meet specifications?
g. Was all equipment used calibrated?
h. Were all workers qualified in accordance with requirements?
i. Is there adequate cleaning OQE?
j. Were work procedures adequate?
k. Was cleanliness of breathing gas and O_2 systems maintained, re-established?
l. Review REC Log to ensure it conforms to the requirements of Appendix I.

Figure 4-2 (Cont'd)

☐ 3. Review JSN, CSMP, EDL, and the Equipment Status List (ESL) to determine if all SOC repairs have been conducted under REC as required.

a. Review JSN/EDL for SOC work performed without a REC.
b. Check for traceability on SOC items.

☐ 4. Review all required maintenance within the SOC.

a. Is the PMS current to the latest revision and marked as SOC PMS?
b. Are NAVSEA interim MRCs held/scheduled?
c. Are the schedules complete and approved?
d. Was the required maintenance accomplished in accordance with requirements?
e. Did the maintenance actions performed meet the specifications?
f. Was it accomplished at the required periodicity?
g. Was the work accomplishment recorded properly (REC, PMS schedule)?
h. Is the SOC PMS accomplishment properly documented?
i. Is the correct revision of PMS used?

COMMENTS: _____
_____

☐ 5. Review all Departures from Specification for SOC items for the period since the last survey.

a. Were departures generated for all necessary items?
b. Was the proper review accomplished? Is there adequate technical justification?
c. Was correct approval obtained?
d. Check for overdue actions on departures.
e. For conditionally approved departures, have conditions been met?

COMMENTS: _____
_____

Figure 4-2 (Cont'd)

☐ 6. Review the results of the most recent internal survey performed by the Sustaining Activity. This review should include the corrective actions taken and the incorporation of appropriate items into the SCA survey.

a. Review/Rollover outstanding SCA survey cards.

☐ 7. If installed, review all emergency battery reports for the period and make a note of the general battery condition.

a. Was the information recorded on the emergency battery reports in accordance with specifications?

☐ 8. Review Temp Mods.

a. Have all Temp Mods been properly approved for the particular configuration of the DSS?
b. Do the Temp Mods have all necessary documentation to support installation, including documentation required by the approval document?
c. Are installed Temp Mods listed?

☐ 9. Review Technical Manuals and OPs/EPs for incorporation of the most recent changes. (Prior to the survey, list all recent changes subsequent to the last survey. Attach to this survey plan.)

☐ 10. Based on configuration changes, verify that drawings have been updated and that the drawing index is current.

☐ 11. Inspect the DSS and make note of its general condition, with emphasis on the SOC areas.

a. Are items installed in accordance with drawing requirements?
b. Is vital equipment accessible?

Figure 4-2 (Cont'd)

☐ 11.1 Material Inspection Checklist.

a. Viewports for crazing.
b. Hydraulics for seepage.
c. Gaskets for damage.
d. Operability of WT doors.
e. Cleanliness.
f. Preservation.
g. Label plates installed.
h. Gages calibrated.
i. Relief valves calibrated and tagged.
j. Open air piping connections bagged.
k. Structural surface for damage.
l. Mechanical connections tight.
m. Fire extinguishers charged.
n. Wiring secure.
o. Wiring insulation for wear.
p. Fasteners for evidence of corrosion.
q. Fasteners tight.
r. Verification of approved configuration for items not requiring REC for maintenance.

FINDINGS:_____

_____

☐ Current Survey Action:

a. Sustain certification,
b. Sustain certification upon resolution of CAT IA deficiencies, or
c. Suspend certification.

Survey Team Leader:_____

Figure 4-2 (Cont'd)

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Chapter 5
Sustaining Certification

5.1 Introduction

This chapter establishes the policy, assigns responsibilities, and specifies the necessary control procedures for sustaining certification.

5.2 Policy

All components, systems and subsystems shall be maintained and operated such that the DSS will remain in the "as-certified" condition. To maintain this condition all SOC work and all DSS operations shall be performed, documented and controlled in accordance with the requirements of this manual. This includes all SOC work accomplished during availabilities or operating cycles between maintenance periods. All SOC preventive maintenance, corrective maintenance, repairs, alterations and/or modifications shall be accomplished, inspected and tested in accordance with the requirements of this manual. Periodic maintenance monitoring shall be accomplished to identify and correct identified deficiencies or material degradation discovered due to operating and environmental effects.

5.3 Responsibilities

The Sustaining Activity is responsible for sustaining certification subsequent to initial certification.

Sustaining certification requires a cooperative effort of all parties involved with the DSS. This includes individual operational and maintenance units, as well as industrial facilities that perform work on the DSS. The following sections identify responsibilities pertinent to sustaining certification.

5.3.1 Program Manager and SCA Responsibilities

To sustain certification the Program Manager and SCA responsibilities will include the following:

a. The Program Manager shall obtain SCA concurrence for any design changes or proposed alterations on equipment within the SOC or which could change the characteristics or impact the operational capabilities of the DSS SOC. The proposed design change or alteration shall contain an evaluation of the effects of the change on the operational safety of the DSS in accordance with the guidelines of this manual. Accomplishment of design changes and alterations within the SOC without SCA concurrence will result in termination or suspension of certification.

b. The Program Manager is assigned the responsibility for providing the Sustaining Activity with guidance necessary to monitor the material condition of the DSS and to ascertain that the guidance is current. Maintenance pertaining to monitoring material condition is one method to fulfill part of this responsibility.

5.3.2 Sustaining Activity Responsibilities

The Sustaining Activity is responsible for ensuring that the requirements established in this manual and in the Letter of Certification are met. These requirements include:

a. Where re-entry of a certified component, system or a portion of a system is necessary, REC procedures in accordance with this chapter and Appendix I are necessary. The REC method shall provide accountability and shall be maintained in a manner that is suitable for survey.

b. All departures from the certification requirements are fully documented in a form suitable for survey.

c. That periodic maintenance actions are accomplished as specified in the supporting requirements developed for each DSS and adequate OQE is available, in a format conducive to review, during surveys.

d. Accountability of maintenance for each DSS is maintained, and an auditable system of scheduling, performing, and reporting accomplishment of MRCs are established (see also 3-M information and instruction noted in Section 3.9.1 and 3.9.2).

e. An internal survey shall be conducted by the Sustaining Activity and a report shall be submitted to the SCA prior to any required SCA survey to ensure compliance with SOC requirements. The internal survey periodicity shall conform to the requirements of Section 4.1.2.1.

f. The completed maintenance, dive log, including where required pre-dive and post-dive check-off procedures, for all evolutions are retained from survey to survey. The procedures utilized shall be the procedures approved by the Program Manager. Deletion of any item from these procedures must have prior Program Manager approval and SCA concurrence.

g. Obtain Program Manager approval and SCA concurrence for alterations to items within the SOC. This includes the addition of any mission related equipment outside the defined lines of the DSS not previously approved. Any configuration or material change within or to the SOC have Program Manager approval and SCA concurrence prior to accomplishment.

h. Accomplishment and reporting of MRCs in accordance with assigned periodicities approved by the Program Manager and immediate resolution of any unacceptable conditions found as a result of conducting the maintenance procedures or inspections.

5.3.3 Industrial Facility/Supervising Authority Responsibilities

As part of the certification process of those SOC areas worked during an availability or overhaul of a certified DSS at the activity, the maintenance facility or industrial facility responsibilities shall include:

a. Obtaining up-to-date copies of the SOC Notebook, and any other documentation required to determine the SOC, the current configuration, and any other unique certification requirements for the DSS.

b. Accomplishing all necessary installations, repairs, modifications and inspections to the requirements of this manual and other governing specifications, standards and directives.

c. Implementing and monitoring REC in accordance with this chapter and Appendix I where work control of a certified system or portion of a system is required.

d. When performing work under a DSS re-entry document, providing all necessary certification OQE to support final REC closeout.

e. Submitting to NAVSEA, via the chain of command, any proposed modification within the SOC boundaries not previously identified or approved by the Program Manager. Modifications shall comply with the requirements of Chapter 3.

f. Upon completion of work, reporting in writing to the appropriate authority that certification has been sustained in all areas worked on by the activity.

5.4 Sustaining Certification Control Procedures

To sustain and maintain control of a DSS subsequent to initial certification, it is necessary to provide a high level of confidence that any and all work accomplished within the system was authorized and executed by a process that provides documented evidence which will withstand thorough review, evaluation and investigation during the operational life of the system.

The following sections describe certain areas of control and support necessary to sustain certification. The following requirements shall apply to all work accomplished within the SOC.

5.4.1 Re-entry Control

REC is a formal process consisting of implementing procedures and instructions which define and detail access into a certified system, and the precautions which must be taken to restore the DSS to an "as-certified" condition. A "re-entry" is initiated any time that the boundary of a "certified" system is disturbed (e.g., breaking a mechanical joint or a silver brazed or welded joint, removal of a valve bonnet, repairing a gland, repairing or replacing electrical system components, etc.). Re-entry includes any and all work including testing of equipment/systems within SOC systems from first entering to final testing and return to service. Appendix I provides the intent and an example of a process which can be implemented for REC.

5.4.2 Work Procedures

When the REC package does not identify all of the certification documentation and guidance needed for work accomplishment, work procedures shall be used in conjunction with and to augment the REC effort when working within the SOC. The work procedures for the SOC system shall be stand-alone control processes.

Work procedures shall provide specific control points within the processes where independent inspections must be accomplished, e.g., weld joint fit-up and tolerances, correct valve internal installation prior to valve assembly, verification of O-ring and packing installation, insulation checks, etc. Either the REC or the associated work procedure shall identify, to the worker, the instruction or specific parts of it that provide guidance for each step or action to be accomplished. The work procedure shall include a revision process in order to change the work procedures and control the requirements when the scope of work is changed, e.g., weld repair of a valve body where the initial scope of the work required only replacement of the seats but subsequent inspection showed weld repair of the body was also required. Written work procedures shall be used to accomplish the following:

a. Invoke technical requirements and define the specific parts of the reference documents required in order to accomplish the specified work.

b. Define and invoke inspection criteria that will:

(1) Identify what inspection data is required.

(2) Specify who must accomplish inspection (i.e., shop or inspection branch).

(3) Specify in-process steps in the procedure where these inspections shall be accomplished.

c. Identify specific testing and test record requirements.

d. Identify the documentation necessary to prove that material integrity of the DSS will be maintained.

5.4.3 Planned Maintenance Procedures

Periodic monitoring of the DSS material condition is required to ascertain that degradation through use, age, or environment does not cause the material to fall outside of the specification requirements. Monitoring consists of the preventive maintenance test and inspection procedures required to ensure early identification of degradation to systems and equipment within the SOC. The monitoring procedures provide specific requirements as to when, where and how the test or inspection shall be conducted. The procedures detail the extent of test or inspection; provide procedures to measure the material condition; acceptance criteria; required monitoring intervals and specific requirements for recording and reporting data.

All planned maintenance (e.g., PMS) conducted on systems or components within the SOC shall be accomplished using only approved maintenance procedures (e.g., MRCs). The accomplishment of planned maintenance on SOC equipment and systems requires strict adherence to the procedures. When the procedures indicate spare parts are required, they shall be drawn only from controlled storage. If the spare part is to be used in a clean system, it must contain, within its packaging, a tag indicating it has been cleaned in accordance with the applicable approved procedure, or be cleaned prior to use.

The requirements specified in each maintenance task within the SOC are formally approved by the Program Manager. Changes shall be accomplished in accordance with the requirements of Section 3.9.

5.4.4 Temporary Modifications

Operations are frequently assigned to DSS units which require special equipment or modification of the unit on a temporary basis. This section provides guidance for the approval, installation and removal of Temp Mods on DSSs. The Sustaining Activity or User Activity will obtain formal approval for any Temp Mods prior to installation in a DSS from the Program Manager. The request record should contain the following minimum information:

a. Purpose and description of Temp Mods.

b. Mounting details (i.e., type fasteners, welding requirement, etc.).

c. Electrical details (i.e., power requirements, voltage, amperage, type of connectors, length and type of cable, etc.).

d. Weight/moment compensation, including height above baseline, fore/aft location, port/stbd location, weight in pounds.

e. Provide a matrix to show the impact on stability, including weight/moment (addition or removal), height above baseline, fore/aft location, port/stbd location, weight in pounds in air and water if applicable.

f. Impact on other unit systems or design specifications (i.e., electromagnetic interference, access to vital equipment, etc.).

g. Implodables that are part of Temp Mods shall meet the requirements of Appendix C.

h. Temp Mod toxicity and flammability requirements in accordance with Appendix F.

i. Routine/periodic preventive maintenance requirements.

j. Any special or unique certification requirements not otherwise identified.

Temp Mod records will be maintained in a manner suitable for audit and reviewed during surveys. If a Temp Mod is depth restricted, ensure it is identified as such at the end of the Temp Mod number. Maintain a Temp Mod sequential number record that includes request, approvals and clearance. When a Temp Mod is removed, clear the Temp Mod by making a clearance report to the Program Manager.

Installation of previously approved Temp Mods on the same unit is authorized only when the approval documentation is available and contains approval for re-installation for continuing use. Temp Mods approved for use on one DSS unit will not be installed on another DSS unit without prior approval of the Program Manager with SCA concurrence.

5.5 Test and Trials Stage

The maintenance concept for DSSs includes a number of short term availabilities between major availabilities. The sequencing of events and certification actions leading up to initial or post overhaul trials and initial certification or reinstatement of certification are contained in Chapter 3.

5.6 Sustaining Certification Survey

Subsequent to the initial certification, sustaining certification surveys shall be performed in accordance with the requirements of Chapter 4.

5.7 Operating Limits

The DSS shall operate within the limits specified as part of the requirements for sustaining certification. Operation outside of the authorized limits may result in suspension of certification. The Sustaining Activity shall report any violation to NAVSEA stating the cause or justification for the violation.

The SCA shall be advised of any failure or maloperation experienced by, or damages sustained to, any item or system within the SOC. These may include, but are not limited to, excursions below certified test depth or above certified pressure, physical damage, grounding, entanglements, fires, and emergency ascents or depressurizations. (It is not intended that these situations include failures which only temporarily interrupt the operational capability of the DSS and are correctable by routine repairs.) Further, a report shall be submitted by the Sustaining Activity by the fastest means possible to NAVSEA containing an evaluation of the extent of damage, proposed repair methods, probable cause of the emergency (e.g., personnel error, operations, systems, component failures, etc.), operating restrictions and recommended corrective action to prevent recurrence if applicable.

5.8 Continuation of Certification

For special cases when certification is granted for a specific period of time and it is deemed necessary to retain a certified system the following actions are required:

a. At least six weeks prior to the expiration date of certification, the Sustaining Activity must submit an official request to NAVSEA for continuation of certification for a specific time period, and include written rationale for the continuation together with a status of maintenance and system condition.

b. NAVSEA may conduct on-site surveys to verify system material condition and ensure that existing certification requirements have been properly sustained.

c. The Sustaining Activity reports by message to NAVSEA completion of any Category IA and IB survey deficiencies.

d. The SCA grants continuation of certification for a specific period of time contingent on the overall DSS material condition.

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APPENDIX A

CATEGORIZATION OF SOC MATERIALS AND COMPONENTS

A.1 INTRODUCTION

This appendix contains guidelines for evaluating and assigning categories to SOC materials and/or components based on a knowledge of their history and service experience in the anticipated operational environment. The proposed application, configuration, design concept, joining technique, etc., is compared to a similar usage from previous naval applications for determination of the proper categorization. If the proposed application cannot be correlated with historical naval experience, additional proof or validation testing to justify the intended use must be considered.

It is emphasized that the material and component categories detailed in this manual should not be confused with the hazard level categories of MIL-STD-882. The material and component categories of this manual were conceived to aid in assessing the probable reliability of materials and components in specific DSS applications. They do not correspond to the MIL-STD-882 hazard level categories which are based on the significance of possible failure of such materials or components.

The Program Manager must justify the use of materials and intended applications as proposed in the design of the DSS within the expected service environments. All of the materials considered to be within the SOC shall be identified. Their environmental exposure and location should be addressed and verification of their compatibility with each other evaluated or demonstrated and documented.

It is anticipated that new materials and new applications for proven materials may be employed. It is not the intent of this manual to limit materials and their applications. The intent is to permit the use of new material or materials in new applications whenever sufficient data or reasonable rationale exist to show that the material adequacy of the DSS will be assured. The lesser the amount of available information and experience with a material or application, the greater the burden upon the Program Manager to justify the adequacy of the proposed material or application. For the purpose of certification, all materials and/or components are grouped into the following three categories. Their appearance in more than one category is a result of the above rationale.

A.2 CATEGORY 1 MATERIALS

Category 1 materials and components are those for which considerable operating experience is available. For hull/pressure vessel materials and external piping, this would include experience in fabrication, testing and operation in a seawater environment. For piping systems, compatibility with both the internal and external medium would have to be known.

Tables A-1 through A-3 list typical materials and/or components with their application and category. The specifications listed are representative of specific requirements for the material identified and are provided for guidance. Untested or unusual configurations or applications of these materials and/or components might place them in a different category. Also, exposure to unusual environmental conditions such as radiation or unusually high operating temperatures has to be considered to determine if these materials should be evaluated in a different category.

Table A-1. Category 1 Pressure Hull/Vessel Materials - Ferrous

Material	Stock	Specification	Remarks
HY-80/100	Plate Forging Bars Castings Heads	MIL-S-16216* MIL-S-23009* MIL-S-21952* MIL-S-23008* MIL-S-24451*	Category 1 when fabricated and welded to requirements of NAVSEA T9074-AD-GIB-010/1688, or ASME PVHO-1
Carbon steel for pressure vessels for moderate and lower temperature service	Plate Plate Plate Forging	MIL-S-22698* ASTM A537** ASTM A516, Grade 70** ASTM A350**	NAVSEA T9074-AD-GIB-010/1688, or ASME PVHO-1

* These military specifications include impact property requirements for HY-80/100 material in military applications. Consideration will be given to lower impact values for HY-80/100 where the material meets the toughness requirements of ASME PVHO-1, Safety Standard for Pressure Vessels for Human Occupancy.

**When specified to a maximum Nil Ductility Temperature of 60°F below the minimum design temperature, or a dynamic tear value of at least 200 ft/lbs from a 5/8-inch specimen tested at the minimum design temperature.

Table A-2. Category 1 Piping, Electrical and Life Support Systems Materials and Components

Material	Stock	Specification
Stainless steel	Pipe and Tubing	MIL-P-24691 ASTM A312 ASTM A269
	Forgings Flanges and Fittings Castings	QQ-S-763, ASTM A336 ASTM A350 ASTM A352
Ni-Cu (Monel)	Cast	ASTM A494, MIL-C-24723
	Wrought	QQ-N-281
	Tubing	MIL-T-1368 Class A
70/30 Cu-Ni	Cast	ASTM B369
	Wrought	MIL-C-15726, ASTM B171 Alloy 715
	Tubing	MIL-T-16420, ASTM B466 Alloy 715
Valve Bronze		ASTM B61
Oxygen Valves		MIL-V-24439
Aluminum Bronze	Cast	MIL-B-24480 ASTM B271 Alloy 958
	Wrought	ASTM B150 Alloy E 63200 ASTM B148 (temper annealed per MIL-B-24480)
Compressed Gas Flasks		MIL-F-22606 ASME Boiler and Pressure Vessel Code, Section VIII, Division 1
CO_2 Absorbent	Calcium Hydroxide	
	w/NaOH	Soda-Sorb: WR Grace Sofnolime; Molecular Products: Grade 408L with no indicator
	w/BaOH	Baralyme: Commercial
	Lithium Hydroxide	MIL-L-20213
Electrical Equipment		MIL-E-917
Electronic Equipment		MIL-STD-2036

Table A-3. Category 1 Mechanical Bolting Material

Material	Stock	Spec
Ni-Cu-Al Alloy (K-Monel)	Round Stock	MIL-S-1222
Ni-Cu	Round Stock	MIL-S-1222

A.3 CATEGORY 2 MATERIALS

This category includes materials and components which have not been extensively used in their specific, intended applications, but are classified as conventional due to identification by military or federal specifications, or recognized American commercial standards. Materials or components available as standard stock items and built to a recognized commercial or federal standard will be considered in this category. Components that are presently considered to be in Category 2 are certain types of aluminum, titanium, and some steels that are fabricated, welded and heat treated for use as pressure hull/vessel and exostructure. The determination of acceptable properties and allowable operating stress values will be based on the recommendations and supporting information and data provided by the Program Manager and approved by NAVSEA.

A.3.1 Structural Materials

For pressure hull/vessel and other structural materials, the Program Manager should submit the following information as justification for the use of a Category 2 material:

a. The applicable military, federal, or commercial specification with a detailed list of exceptions or additions.

b. Material properties of the base metal in the condition it will be used and, if the material is to be welded, of the weld metal and the material in the heat affected zone.

c. Tensile properties, including, but not limited to, tensile strength, creep behavior, yield point, percent elongation, reduction of area, elastic modulus, and stress-strain curves (tension and compression), for the material at its service environment temperature. The material specimens tested should represent any defects and variations in material properties introduced by manufacturing and fabrication processes. Should the preparation of specimens with intentional defects or property variations prove unfeasible, the Program Manager may fabricate a first article and conduct inspections and destructive testing. If the first article is satisfactory, all follow-on production articles that meet or exceed the quality of the first article will satisfy this part of the requirement.

d. Impact and fracture toughness properties over the material temperature range for the intended service environment (e.g., transition temperature and shelf energy values). Desirable tests include Charpy V-notch transition curves and dynamic tear as well as drop-weight tests per ASTM procedures, and/or explosive bulge tests. Where appropriate, the Program Manager should show that the materials' fracture toughness properties in the applicable environment are adequate for its intended use. In this regard, a fracture mechanics type of test is useful to study the effect of seawater on fracture resistance.

e. Proof of weldability and fabricability (if fabrication process includes welding) in accordance with the testing requirements of NAVSEA T9074-AD-GIB-010/1688 or approved industrial standard. These test results shall include tensile and impact properties of both weld metal and heat affected base metal. A list of specific applications should also be provided. Specific considerations include quantities and thickness of material, welding processes used, inspection standards used, manufacturer's name and fabrication experience, component service environment and length of service, pre-weld and post-weld heat treatments, if any, and the type of requirements and inspections required of the material supplier in the material purchase specifications.

f. Fatigue data, preferably data in the low-cycle range (below 10,000 cycles), which considers the effect of the environment. Testing conducted to generate the required data must include loads equivalent to the peak stress encountered during operation at maximum design depth.

g. Basic process to be used in producing the material. This includes electrodes if the fabrication process involves welding.

h. Data over a sufficient time period to justify the adequacy of the materials with respect to general corrosion and to stress corrosion cracking in its intended environment.

i. NDT requirements to be applied to base material and weld joints, as appropriate.

A.4 CATEGORY 3 MATERIALS

Category 3 materials and components include items for which definitive information and experience are not available. Proof and validation of acceptability for these materials or components justifying proposed acceptance criteria must be provided by the Program Manager. The design, fabrication, testing, and maintenance requirements for Category 3 materials will be submitted for SCA concurrence. This manual neither specifies acceptance tests for new components or materials nor arbitrarily defines allowable operating parameters. For example, the Program Manager must

demonstrate the effect of defects, manufacturing tolerances, and production variations upon the reliability of the material or component by appropriate model and/or prototype testing in a simulated service environment.

Examples of Category 3 pressure hull/vessel and other structural materials are those which are generally characterized by low ductility such as ultrahigh strength metals, solid glass or carbon fiber reinforced plastic and ceramic material.

A.4.1 Pressure Hull/Vessel and Other Structural Materials

The Program Manager must demonstrate that components fabricated using the new material possess a factor of safety that can be compared to the proven materials used in a similar application. As a minimum, the Program Manager will submit to the SCA for technical review and approval the following information as justification for the use of a Category 3 material.

a. Material chemical properties.

b. Material mechanical properties including changes to properties such as proportional limit stress as a result of material forming.

c. Basic process to be used in producing the material. Sufficient information is required to demonstrate that the procedures ensure that repeatable material properties are obtainable by the process used.

d. Data demonstrating material and structural performance when subjected to dynamic shock resulting from explosively jettisoning external equipment, and implosion of a flotation sphere or any other airbacked component or equipment mounted on or transported by the DSS.

NOTE: While the above paragraph establishes performance criteria (must survive) for the candidate material under the conditions of explosively jettisoning external equipment, it does not impose pass/fail criteria for material performance during implosion shock loading. That is, it is not required to demonstrate that the material would survive the shock; rather, the requirement is to demonstrate how the material actually performs. The resulting data will be used to conduct the evaluation of implodable and explodable volumes specified in Appendix C.

e. Effects of flaws such as cracks or defects on material performance.

f. Effects of temperature on material performance and resistance to crack propagation.

g. Results of tests to destruction of samples fabricated from the materials and comparison of these results with the design basis predictions of the failure point. These include implosion and/or rupture test of scale models of the proposed structure as applicable.

h. Failure modes and effect analysis.

i. Service environment fatigue data in the high-strain, low-cycle range (less than 10,000 cycles). Testing conducted to generate the required data must include loads equivalent to the peak stress encountered during operation.

j. Data covering an extended time period establishing the adequacy of the material with respect to general corrosion and to stress corrosion cracking in the applicable service environment.

k. Fabrication characteristics, including data verifying the repeatability of results.

l. NDT requirements to be applied to the base material and joints as appropriate.

m. Hazards involved in fabrication or use of material with respect to toxicity or flammability.

A.5 VIEWING WINDOW MATERIALS

Information on viewing window materials will be submitted in accordance with the requirements for pressure hull/vessel and other structural materials listed above. Particular emphasis should be placed on the cold flow or creep characteristics of the window material under the most adverse service temperature conditions. The impact of flaws in viewing window materials also needs to be addressed. Viewports that comply with the requirements of ASME PVHO-1, when manufactured of acrylic plastic meeting ASME PVHO-1 Appendix A specifications and installed in submersibles or pressure vessels for human occupancy, are considered Category 1. All other viewing window materials are considered Category 3. The OQE demonstrating the satisfactory fabrication and testing of viewports shall be equivalent to that required by Appendix A to ASME PVHO-1.

A.6 FLOTATION MATERIALS

Materials used for flotation may be liquid, solid, or gaseous. As a minimum, information covering the following points shall be submitted:

a. The applicable military, federal, or commercial specification with a detailed list of exceptions or deletions.

b. Data demonstrating that the material presents no hazards to DSS personnel involving toxicity due to its application and location.

c. Specific gravity as a function of pressure and temperature.

d. Sustained hydrostatic collapse load, creep behavior, moisture absorption, and cyclic fatigue life of solid buoyant materials in a seawater environment.

e. Information establishing that material is nonflammable under the conditions of use or, if flammable, that suitable precautions have been taken in its application and location.

f. Information to establish that the material can perform satisfactorily as a buoyancy material in the proposed applications. Items considered should include at least the long-term storage of the material including cyclic temperature effects in an air environment, exposure to the environmental factors of pressure, temperature, humidity, and so forth, and compatibility with both seawater and any containment or protective materials.

A.7 HYDRAULIC SYSTEM FLUIDS

As a minimum, the Program Manager shall submit the following:

a. The applicable military, federal, or commercial specifications, including a detailed list of exceptions or deletions.

b. Information covering resistance to deterioration, flammability, and compatibility with selected hydraulic system components.

c. Information relating to possible toxicological hazards with the fluid based on its application and location.

A.8 ELECTRICAL/ELECTRONIC SYSTEM MATERIALS

The Program Manager will submit the following information as justification for the material use.

a. If a material is not purchased to a MIL-SPEC, a specification sheet shall be made available for review and approval by the Program Manager along with production type test data to demonstrate the equipment/component adequacy.

b. If the material is purchased to a MIL-SPEC all test data required by the MIL-SPEC shall be made available for review and approval.

c. Guidance for electrical/electronics systems are contained in MIL-E-917/MIL-STD-2036, respectively.

A.9 FAIRING AND MISCELLANEOUS NONSTRUCTURAL MATERIALS

As a minimum, the Program Manager will submit the following:

a. The applicable military, federal, or commercial specifications, including a detailed list of exceptions or deletions.

b. Information covering resistance to deterioration in seawater, compatibility with mating structural materials, and resistance to dynamic loads such as wave slap and loads encountered in operating, handling, or docking the DSS.

A.10 LIFE SUPPORT SYSTEM MATERIALS

As a minimum, the Program Manager will submit the following:

a. The applicable military, federal, or commercial specifications, including a detailed list of exceptions or deletions.

b. Data covering extended time periods justifying the expectancy of the material or component to perform in its expected temperature, pressure, humidity, and atmospheric conditions to which it will be subjected.

c. Data demonstrating that the material or component presents no toxic hazards to DSS personnel due to its application and location.

d. Data establishing that the material or component is nonflammable under the conditions of anticipated use or, if flammable, that suitable precautions will be taken based on its application and location.

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APPENDIX B

DESIGN FACTORS FOR DEEP SUBMERGENCE SYSTEMS

B.1 INTRODUCTION

The fundamental purpose of a DSS is to safely take personnel to a specified depth, maintain life at that depth and perform some task, then safely return the personnel to the surface. A typical mission may take hours or, if saturation diving is involved, days or even weeks. This appendix is provided to make the Design Agent of a DSS aware of special hazards to human beings and to suggest controls for those parameters which can reduce the hazards.

This appendix is not to be considered as all-inclusive, but is intended to provide an indication of those areas of design in which experience exists and in which design parameters have been established. The Design Agent must review the requirements of the specific DSS with which he is working, then coordinate those requirements with the design requirements of this manual.

Since emergent DSS mission requirements, technologies and configurations will inevitably result in design conditions beyond the scope of existing experience, application of the guidelines herein will not always assure a safe DSS nor will it always assure acceptance of the design. The design will consider system redundancy and protective devices necessary for ensuring the safety of DSS personnel during emergency operations.

B.2 STRUCTURAL DESIGN CONSIDERATIONS

This section provides general philosophy for the design and analysis of pressure hulls/vessels, and hard structures that are within the SOC. The information does not necessarily cover all design attributes that may need to be evaluated by the Program Manager in the design/analysis of a DSS. In the design analysis, consideration shall be given to all conditions such as effects of shock, vibration, creep, thermal transients, or material deterioration due to radiation effects which may be applicable to a specific design and/or application.

DSS pressure hull/vessels and hard structures are complex structures containing penetrations for piping, electrical cables, hatches, viewports, and other appurtenances, as well as geometric discontinuities, such as cone-to-cylinder intersections, and saddles for support systems. The physical properties of the materials from which pressure chambers are fabricated such as the modulus of elasticity, Poisson's ratio, yield strength, ultimate strength, fatigue strength and fracture toughness interact in a complex fashion. In addition, structural buckling is often a controlling factor for DSSs with compressively loaded shell structures (including thin elliptical heads internally

loaded). As such, a rational design procedure, which accounts for fatigue, stress, fracture, buckling and all pertinent material properties shall be applied to the design of the pressure vessel's hard structure in order to ensure a safe and effective structure. The burden of proof is upon the Design Agent to design a pressure vessel/hard structure and demonstrate, by use of analytical and experimental means, that the structure will function as intended for the required life of the structure.

B.2.1 Fatigue

A fatigue analysis shall be submitted, unless the rationale for not performing the analysis has been accepted by the Program Manager with SCA concurrence. This fatigue analysis may be based on specimen and/or model tests. Suitable fatigue strength reduction factors shall be applied to the specimen or model test results to account for variations in properties, scatter in test results, and the uncertainties involved in applying specimen and model fatigue data to fabricated full-scale structures. This fatigue analysis must consider at least the following design parameters:

a. Magnitude and nature of peak stresses. Stress concentration factors used in the calculation of peak stresses shall be based on experimental data on similar structures.

b. Material properties and method of fabrication.

c. Maximum deviation in material thickness, assembly techniques and allowable flaws.

d. Geometry of structure and details of penetrations and attachments.

e. Fabrication history, stress history and operating history.

f. Effects of residual stresses, thermal stresses, and strain rate.

g. Type and method of loading and environmental conditions such as corrosion and/or erosion.

h. Maximum anticipated number of load cycles.

When the pressure vessel and hard structure are constructed of Category 3 material (see Appendix A), sufficient destructive fatigue tests of full scale prototypes or models must be performed to experimentally determine the fatigue life of the design.

B.2.2 Fracture Toughness

The Program Manager shall ensure that all materials used in fabricating the pressure hull/vessel, hard structure, or other structural components within the SOC have adequate resistance to fracture. Specifically, the design analysis submitted by the Program Manager shall demonstrate that brittle-fracture or low-energy test failures are not possible modes of failure by considering at least the following:

a. Magnitude, nature and rate of stresses (both applied and residual).

b. The maximum temperature range to which the structure may be subjected in service.

c. The size, location, and number of flaws initially present in the material and those that occur as a result of cyclic operations.

d. Environmental conditions such as corrosion and/or erosion. Specifically, the environmental effects on crack initiation and propagation (e.g., stress corrosion cracking) must be evaluated.

e. The effects of creep and strain cycling on fracture toughness.

f. Localized effects due to penetrations, attachments, and other hull or component restraints (i.e., stress risers).

g. The effect of fabrication processes and heat treatments on the fracture characteristics of the material. In particular, for welded construction, properties of the weld metal and base metal within the heat affected zone and resultant induced internal stresses shall be considered.

h. Material thickness.

The material properties used in the fracture analysis should be based on appropriate tests such as tensile and compressive tests, KIc, KIscc, Charpy V-notch transition curves, dynamic tear tests, drop-weight tests, and explosion bulge tests as discussed in Appendix A. Where appropriate test data is not available fracture mechanics-type tests shall be conducted. Further, the design analysis must consider possible variations in material properties and, in particular, the effect of material thickness on fracture characteristics. The structural design basis used by the Program Manager for the analysis of brittle fracture should be verified by destructive testing of pressure hull and component models and structures or, where possible, by reference to existing information and service experience.

For Category 3 materials that are not ductile in the usual sense, the Program Manager must demonstrate that, for all considerations listed above, a sufficient margin against catastrophic brittle fracture is provided.

All plates, parts, and components, regardless of category, must demonstrate adequate strength and toughness over the range of design operating temperature. Toughness characteristics of ferrous materials shall be referenced to the Nil Ductility Temperature.

B.3 DESIGN STRENGTH PARAMETERS OF EXTERNALLY LOADED PRESSURE HULLS/VESSELS, HARD STRUCTURES

NOTE: Pressure hulls/vessels, hard structures, and components which are subjected to both external and internal pressure shall be designed to meet the requirements of both Sections B.3 and B.4; and shall be tested in accordance with the test requirements of both sections.

For pressure vessels and hard structure of DSSs subjected to greater external pressure than internal pressure, the Design Agent shall provide evidence that the structure has sufficient collapse strength to withstand maximum operating pressure (including a factor of safety).

In general, the modes of failure in a pressure vessel subjected to external pressure are caused by either elastic or inelastic instability. The Program Manager shall demonstrate that the collapse pressure of the hull and hard structure is at least 1.5 times the maximum operating pressure under loading conditions (environment, loading rate, and duration) representative of those expected in service. Exceptions to this criteria require SCA approval. The collapse pressure is defined as the lowest pressure at which any one of a series of nominally identical hull structures would collapse. As such, the design collapse pressure (analytical or experimental) must take into consideration the effect of basic material characteristics, including creep, ductility, and anisotropy, and must account for statistical fabrication and geometrical variations to assure adequate reproducibility. Examples of pertinent variables include in-service material reproducibility, fabrication flaws and defects, hull openings and intersections of different shells of revolution and attendant reinforcement(s), residual fabrication stresses, and deviations from the nominal geometry (i.e., flat spots, mismatch, frame tilt, out-of-roundness, out-of-fairness, and out-of-sphericity). Out-of-roundness, out-of-sphericity deviations, and material discontinuities are of major concern in the design and fabrication of externally loaded pressure vessels. Even small deviations in a sphere or cylinder's geometry will significantly weaken a pressure vessel. Additionally, the Design Agent must bear in mind that seawater corrosion must be taken into account when the pressure vessel is to be submerged. The sections that follow give the requirements that shall be met in order to accomplish this objective.

B.3.1 Inelastic Stability

For Category 1 and 2 materials used in stable pressure vessels and hard structures (i.e., stiffened or unstiffened shells which permit the level of load-induced membrane stresses to approach the material yield point at collapse pressure), the collapse pressure must be no less than 1.5 times the maximum operating pressure. In determining the pressure at which collapse occurs, all fabrication and design-induced restraint and geometrical variables must be considered since the strength of moderately stable structures can be detrimentally affected by such variables.

For Category 3 materials, an appropriate ratio of collapse to operating pressure shall be justified by the Program Manager.

B.3.2 Elastic Stability

For stiffened or unstiffened hull structures fabricated from either Category 1 or Category 2 material and having a propensity for failure in an elastic instability mode (i.e., collapse occurring at actual stress levels appreciably below the material yield point), the collapse pressure at which failure due to instability occurs must be no less than 1.5 times the maximum operating pressure.

For Category 3 materials, an appropriate ratio of collapse to operating pressure shall be justified by the Program Manager.

B.3.3 Stress Analysis

The Program Manager shall perform a complete stress analysis of the pressure vessel and hard structure and demonstrate that all stresses are within the design criteria and that its fatigue life is adequate for the intended life of the DSS. For Category 1 and 2 materials, the static stress levels shall be limited to the values below.

a. The average shell membrane stress at maximum operating pressure shall be limited to two-thirds of the minimum specified yield strength of the material.

b. The highest combined value of average shell membrane stress and bending stress (excluding effects of local stress concentrations) at maximum operating pressure shall be limited to three-fourths of the minimum specified yield strength of the material. The effect of all loading conditions, transitions, and stiffener-to-shell connections must be considered.

c. The maximum peak stress at any point in the hull, including effects of local stress concentrations, shall be limited to the minimum specified yield strength of the material and shall take into account all fatigue considerations as discussed in Section B.2.1.

To ensure an adequate fatigue resistance for some designs using Category 1 and 2 materials, it may be necessary to reduce the level of allowable stress below that given in paragraphs B.3.3.a, b, and c above.

The Design Agent shall calculate stresses in the pressure vessel and hard structure by means of recognized stress formulas or proven computer programs. The validity of the stress analysis methods used shall be demonstrated by experimental results, manually obtained predictions, and prior experience with similar structures.

For hulls and hard structures constructed of Category 3 material, the foregoing design requirements and guidelines may not be appropriate or adequate. Therefore, the design basis used must be comprehensive and at least as conservative as the design basis for Category 1 and Category 2 materials.

B.3.4 Verification of Calculated Collapse Pressure

NOTE: The requirements of this section only apply to the prototype of each design. All IDENTICAL reproduction of a prototype shall be tested to the requirements of Section B.3.5, unless required otherwise by the Program Manager.

For pressure vessels, hard structures, and penetration fittings made of Category 1 and 2 materials, the calculated collapse pressure must be verified by model testing or use of existing destructive and/or nondestructive tests. There are three alternative methods which can be used. The method chosen shall have SCA concurrence.

a. When comparable hull geometries and identical materials have been successfully tested to a pressure at least 1.5 times the maximum operating pressure of the structure, use of this test data can be substituted for destructive testing of the structure under review. In instances when this method is applicable, and when even minor differences exist between the hull structure tested and that requiring verification, the differences must be analyzed and submitted to the Program Manager for approval.

b. For new designs that do not fall within the parameters described in paragraph B.3.4.a, the calculated collapse pressure may be verified by performing representative destructive model tests, either full or reduced scale. When such testing is performed, the structural model shall be sufficiently large to contain representative prototype geometries, material properties and fabrication process restraints, tolerances, and residual stresses.

c. Testing of the actual hull structure to 1.5 times the maximum operating pressure will be accepted as verification of the calculations. When this option is chosen, the calculated collapse pressure must be greater than 1.5 times maximum operating pressure by a margin sufficient to preclude damaging the structure during the test. Program Manager approval of the safety margin shall be obtained prior to the test.

For Category 3 materials, the ratio of collapse pressure to maximum operating pressure may need to be greater than 1.5, depending on the material characteristics. Additionally, the calculated collapse pressure and the reproducibility of this collapse pressure shall be verified by destructive model tests and/or appropriate destructive tests of a duplicate prototype hull. An acceptable destructive model test is one performed on a model which incorporates all structural details of the full-scale structure and whose scale is such that the mechanical properties of the material are either identical to or differ by a known factor or magnitude from those in the full-scale structure built from the same material. Program Manager approval shall be obtained for the factor of safety and all test parameters.

B.3.4.1 Testing Procedures/Test Instrumentation

For all structures, a detailed test procedure shall be developed and provided to the Program Manager for review and approval prior to testing. The test shall be conducted at a pressure which is at least 1.5 times maximum operating pressure (or by the approved factor of safety in the case of a Category 3 material) and shall be of sufficient duration to demonstrate that sustained loading does not produce permanent deformation or damage in the structure at maximum operating pressure. The test procedure shall include a detailed strain gage plan which specifies the number, type and location of all gages. The test procedure shall duplicate the loading conditions expected in service and, where applicable, shall be such that the mode of failure is identifiable. For instance, the tested structure should be filled with liquid and vented to prevent total disintegration of the structure during collapse. Upon completion of testing, the recorded strain gage data shall be used to verify the calculated performance of the structure. Subsequent to testing, pressure boundary weld NDT may be specified or required by the Program Manager. The complete test report shall be provided to the Program Manager for approval and SCA for concurrence.

B.3.5 Verification of As-Built Strength (Proof Test)

NOTE: The requirements of this section apply only to identical reproduction of a prototype which has successfully met the requirement of Section B.3.4.

A proof test to at least 1.0 times the maximum operating pressure shall be conducted on all pressure vessels, hard structures, and penetration fittings that are subject to external pressure.

NOTE: "Hard structure" typically refers to DSS components whose function is to enable the storage, transfer, or controlled movement of a working fluid at relatively low system pressure, while resisting the external force due to ambient sea pressure. For example, variable ballast tanks might be classified as hard structure. Volumes external to the pressure hull, designed to maintain a static, dry, nominally one atmosphere environment within the volume for the purpose

of protecting pressure-sensitive components, are usually classified as implodables and are treated in Appendix C. Camera housings and lights are examples of implodable volumes. It is important to note also that components/volumes inside the pressure hull, which themselves may be internally exposed to ambient sea pressure, may be classified as hard structure. This explanation is provided as general guidance and does not preclude the Program Manager from providing justification for classifying a particular component as either hard structure or implodable.

For hull structures which have had full-scale model tests, described in paragraphs B.3.4.b or c, in accordance with Section B.3.4.1, the proof test required by this section does not have to be instrumented.

For hull structures which have not had full-scale model tests described in paragraphs B.3.4.b or c, the proof test required by this section shall be an instrumented (strain gage) pressure test in accordance with Section B.3.4.1, except that the test pressure shall be at least 1.0 times the maximum operating pressure. Subsequent to testing, pressure boundary weld NDT may be specified or required by the Program Manager. The results of this test shall be compared to strain gage data obtained during reduced scale model testing, similar item model testing, and/or calculations. Where multiple pressure vessels or hard structures are fabricated to identical designs, only the first item (i.e., prototype) will require instrumentation during the proof test. All items subsequent to the prototype require proof tests to at least 1.0 times the maximum operating pressure, but need not be instrumented.

B.3.5.1 Proof Testing Procedures/Instrumentation

For all pressure vessels, Program Manager approval of the proof test procedure shall be obtained prior to commencing the proof test. The proof test procedural requirements shall be similar to the model test procedural requirements of Section B.3.4.1.

B.4 DESIGN STRENGTH PARAMETERS OF INTERNALLY LOADED PRESSURE VESSELS/HARD STRUCTURES

NOTE: Pressure hulls/vessels, hard structures, and components which are subjected to both external and internal pressure shall be designed to meet the requirements of both Sections B.3 and B.4; and shall be tested in accordance with the test requirements of both sections.

Internally loaded pressure vessels include hyperbaric/recompression chambers, personnel transfer capsules (PTCs), air receivers, and gas storage flasks. In general, the Program Manager shall demonstrate the structural integrity of the pressure vessel under loading conditions representative of those expected in service. As such, the design must take into consideration the effects of temperature, cyclic loading, creep,

ductility, and anisotropy. Examples of pertinent variables include pressure, temperature, number of load cycles, material reproducibility, fabrication flaws and defects, design tolerances, local stress concentrations, fatigue, vessel openings, intersection of different shells of revolution, reinforcements, residual fabrication stresses, corrosion rates, and deviations from nominal geometry. The design basis should have SCA approval before the design of these items commences.

B.4.1 Stress Analysis

The Program Manager shall perform a complete stress analysis of the vessel or hard structure and demonstrate that all stresses are within the design criteria for the DSS, and that its fatigue life is adequate for the intended service life. For Category 1 and 2 materials, the allowable stresses under internal pressure shall be in accordance with ASME PVHO-1. For Category 3 materials, the foregoing design requirements and guidelines may not be appropriate or adequate. The design requirements used must be comprehensive and provide at least the same degree of conservatism as the design requirements for Category 1 and 2 materials.

B.4.2 Verification of Calculated Design Operating Pressure

For Category 1 and Category 2 materials, the calculated design operating pressure must be verified by model testing or use of existing model test data. There are three alternative methods of verification.

a. Where comparable vessel geometries and identical materials have been successfully tested to a pressure greater than the design failure pressure of the vessel to be certified, use of the existing test data can be substituted for destructive model testing of the structure under review. When this method is used, and even minor differences exist between the hull structure tested and that requiring verification, the differences must be analyzed and submitted to the Program Manager for approval.

b. For new designs that do not fall within the parameters described in paragraph B.4.2.a above, the calculated failure pressure may be verified by performing destructive model tests, either full or reduced scale. When such testing is performed, the structural model shall be sufficiently large to contain representative prototype geometries, material properties and fabrication process restraints, tolerances, and residual stresses.

c. For new or existing vessels, the structural integrity of the vessel to be put into service may be verified by performing a pressure test of the actual vessel to 1.5 times the maximum operating pressure. When this method is used, the calculated failure pressure of the vessel must be greater than 1.5 times the maximum operating pressure by a margin sufficient to preclude damaging the vessel during the test. Program Manager approval of the margin of safety shall be obtained prior to testing.

For Category 3 materials, the foregoing testing requirements may not be appropriate or adequate. Therefore, the testing used must demonstrate at least the same degree of conservatism as the testing requirements for Category 1 and 2 materials.

B.4.2.1 Testing Procedures/Test Instrumentation

For all structures, a detailed test procedure shall be developed and submitted to the SCA for review and approval prior to testing. The test shall be of sufficient duration to demonstrate that sustained loading does not produce permanent deformation or damage in the structure at maximum operating pressure and temperature. The test procedure shall include a detailed strain gage plan which specifies the number, type and location of all gages. The test procedure shall duplicate the loading conditions expected in service and, where applicable, shall be such that the mode of failure is identifiable. Upon completion of testing, the recorded strain gage data shall be used to verify the calculated performance of the structure. The complete test report shall be provided to the Program Manager for approval and SCA for concurrence.

B.5 MISCELLANEOUS PRESSURE VESSELS AND HARD STRUCTURES

It is recognized that many existing pressure vessels were designed, built, and tested to criteria less stringent than current pressure vessel codes and/or may lack OQE which assures that the pressure vessel is in conformance with design parameters. Certification of such a vessel, manufactured from Category 1 or 2 material, shall include pressure testing in accordance with paragraph B.3.4.c and/or B.4.2.c in addition to any other certification attributes or testing deemed necessary by the SCA in order to prove the adequacy of the structure for its intended use.

B.6 DESIGN OF PENETRATIONS INTO AND THROUGH THE PRESSURE HULL ENVELOPE

The DSS Design Agent is responsible for the safe and adequate design of any opening or penetration in the pressure envelope. Article D-5, Section VIII, Division 2 of the ASME Boiler and Pressure Vessel Code provides design criteria for opening shape as well as area replacement and its distribution. Article D-5 does not satisfy the requirements of a fatigue analysis, nor does it include piping loads that may be imposed on the hull fitting and/or shell portion of the pressure vessel. These piping loads, if significant, must be considered when designing the pressure vessel and its penetrations. Alternative design methods may be approved by the SCA on a case basis.

All possible modes of failure, including leakage, must be considered during the design of the system. Sufficient testing must be performed and documented to confirm the structural integrity and leak tightness of each penetration.

All vent, drain, exhausts, or other paths through the pressure vessel, which are not in use during the period that the DSS is pressurized, and which could be potential accidental inlets/exhaust paths, shall be equipped with a means of positively securing or locking against accidental operation. Penetrations with gasketed sealing areas shall have corrosion protection provisions for these areas. The design of shafts which penetrate through the pressure hull shall have adequate protection measures to prevent pullout in either direction if one end shears.

B.6.1 Piping Penetrations

Piping penetrations through the pressure envelope shall be located and arranged so that in the event of flooding, loss of atmosphere or similar emergency, a maximum amount of atmosphere will become entrapped in the DSS. Emergency shutoff capability shall be provided to protect the internal breathing atmosphere from exhaust, full flooding, or contamination.

B.6.2 Electrical Penetrations

The bodies of electrical penetrators and connectors that may be exposed to seawater or spray shall be made of corrosion resistant material. Provisions shall be made to protect the pressure vessel from corrosion in the gasketed areas of the penetrators. Electrical penetrations to the pressure envelope shall be gas/water-tight, even when the connecting cables have been damaged. Stuffing tube-type penetrations of the pressure capsule or other hard structure for new construction are prohibited. If an electrical penetrator which is submerged in the water column contains both positive and negative leads, system design will provide adequate protection against the hazards associated with short circuit at the connector. Section B.11.7.2 contains additional requirements on design of electrical penetrators.

B.6.3 Viewports

The Program Manager shall show that the viewport design is adequate for the system pressure and temperature range, environmental conditions, and expected number of pressure cycles. Each port's field of view within the DSS shall be shown on the system drawings. The materials used shall have adequate fatigue strength for the stress levels incurred over the expected service life of the viewport. Resistance to stresses applied continuously over a long period, as well as cyclic stresses, must be properly considered. Full specification must be made of the materials used; their composition; thermal, chemical, or physical treatment required; dimensions and tolerances; and renewal or replacement criteria. Where necessary, viewports shall be protected from accidental impact or other mechanical abuse. Although the use of a variety of functionally suitable materials for viewports is permitted, acrylic plastic viewports have a high level of success and are recommended above all other types when design parameters permit the use of acrylic.

All acrylic viewports shall conform to ASME PVHO-1.

In-service viewport defect criteria shall consider viewport material and design and are subject to SCA approval on a case basis. Crazing or cracks are not permitted in any viewport. Chips and scratches may be allowed on a case basis depending upon viewport design.

Service life of viewports also depends upon design and is subject to SCA approval. For example, the service life of viewports designed in accordance with ASME PVHO-1 is 10 or 20 years, depending upon the viewport design.

B.6.4 Hatches/Closures

For Category 1 and 2 materials, all closures, including hatches for personnel or materials, port covers (deadlights), and caps or plugs for openings shall have a demonstrated factor of safety at least 1.5 times the maximum operating pressure. The mating flanges of all hatches and doors shall be integral to the pressure vessel shell.

For Category 3 materials, the criteria stated for Category 1 and 2 materials may not be appropriate or adequate. Therefore, the Program Manager may apply an alternative criteria which demonstrates at least the same degree of conservatism as the criteria for Category 1 and 2 materials.

The ease and speed with which a closure can be opened or closed, and whether tools are required to do so, are design considerations. In all cases in which these factors are important, attention should be drawn to them and the appropriateness of the design explained, and SCA approval of their treatment in the design must be obtained.

Hatch/door hinging, closing, locking, and sealing elements must be made resistant to or be protected from abuse due either to rough handling or to possible accidents such as impact from a PTC which is being attached to the DSS in rough weather. Design of the hatches must permit safe operation under specified ship motions and operating conditions.

B.6.5 Seals

Sealing materials and techniques must be shown to be adequate for the range of pressures, gas mixtures, temperatures, vibrations, lubricants, and atmospheric environments specified for the DSS. Seals shall not be subject to failure due to: the effects of a non-lethal extinguishable fire inside or outside the DSS, attack by the fire extinguishing agent used in the DSS, or thermal shock caused by the application of the extinguishing agent. The effects of pressure cycling, stress concentrations, differential thermal expansion, differences in modulus of elasticity, manufacturing tolerances, and aging shall be considered when designing seals.

B.7 MATERIAL SELECTION

Selection of the proper material to be used in the design and manufacture of pressure vessels and hard structures is a critical factor affecting system safety. The specific end use of each structural component must be evaluated on the basis of its operating environment (particularly when used in combination with other materials), loading conditions, and life expectancy. The use of an inappropriate material in a pressure vessel may result in a catastrophic failure and cause fatal or critical injury to DSS personnel. Requirements which provide assurance of adequate material mechanical performance are contained in Appendix A and in Sections B.2, B.3, and B.4. The remainder of this section places needed emphasis on addressing the impact of corrosion, and material toxicity and flammability on DSS design.

B.7.1 Corrosion Resistance

Corrosion effects must be considered during the initial selection of material and throughout the design process. The following are some types of corrosion that must be considered during DSS design.

B.7.1.1 Electrolytic Corrosion

The most common form of corrosion in the marine environment occurs through oxidation and reduction. Electrons pass from the site of oxidation (corrosion) to the site of reduction. The site of oxidation (corrosion) is the anode. The site of reduction is the cathode. The electrolytic path for the electron flow can be supplied or supplemented by a seawater environment. The following are various types of electrolytic corrosion:

a. General/Pitting Corrosion - Large surface areas will corrode due to adjacent points within the area switching from cathode to anode and back again. On the other hand, small areas that start functioning as anodes will continue to do so, causing a pitted surface.

b. Crevice Corrosion - Crevices in or between materials tend to retard the formation of oxide film within these crevices. The oxide film that forms on the surrounding surface will act as a cathode to the crevice's anode causing accelerated corrosion within the crevice.

c. Plate Corrosion - Certain types of metal alloys in sheet or plate form will tend to corrode in planes parallel to the rolling plane of the material.

d. Dealloying - In some alloy compositions, corrosion will attack one or more of the components of the alloy causing weakened material. Some Ni-Al-Brz alloys are particularly susceptible to dealloying when in contact with seawater.

e. Galvanic Corrosion - When two different metals are coupled in the marine environment, one will act as an anode and the other will act as a cathode depending on their position in the galvanic series.

B.7.1.2 Stress Corrosion

Some alloys are susceptible to a specific type of corrosion called stress corrosion cracking, which can occur when the material is exposed to corrosive conditions while under tensile stress. In the case of some high strength alloys, this form of corrosion can be highly accelerated compared to other forms of corrosion. Some austenitic stainless steels are particularly susceptible to stress corrosion cracking at elevated temperatures. Some titanium alloys are susceptible to stress corrosion cracking in gaseous or liquid environments.

B.7.2 Toxicity

a. Any nonmetallic and some metallic materials that can be exposed to a DSS breathable atmosphere shall be considered a potentially toxic material. The toxicity of these materials results from the release of volatile solvents, semi-volatile plasticizers, incompletely polymerized materials, and other vaporized compounds.

b. Materials (e.g., paints, insulations, adhesives, plastics, sealants, gaskets, fabrics, clothing, lubricants, etc.) and other items and equipment containing materials that off-gas toxic compounds, in quantities above the allowable established limits, when exposed to temperatures and/or pressures up to the maximum operating temperature and/or pressure should not be used within a DSS. For paint or adhesives, this requirement applies after drying or curing. Air sampling and analysis of the DSS atmosphere for trace contaminants must be performed during simulated closed hatch operations to verify the above. Toxicity testing for materials and air sampling for the DSS, as well as their approval are covered in Appendix F.

c. Mercury, asbestos, and beryllium are examples of material which shall not be used in a DSS without adequate protection and justification. NAVSEA S9510-AB-ATM-010, Nuclear Powered Submarine Atmosphere Control Manual, provides a list of chemical substances which are prohibited from use in a DSS. Products containing quantities of the chemical substances may or may not be prohibited. Each product must be analyzed separately before it can be approved for use.

B.7.3 Flammability

Any material which will ignite or explode from an electric spark or from heating and which, if so ignited, will independently support combustion in the presence of air or any oxygen enriched atmosphere that may be encountered in the DSS under either normal or emergency conditions shall be considered a potentially flammable material.

Every effort shall be made to eliminate or reduce flammable material from the DSS. It should be noted that materials which are nonflammable at standard atmospheric pressures may be highly flammable at increased oxygen concentrations and/or atmospheric pressures. Flammability testing for materials and equipment is covered in Appendix F.

a. DSS stationary furniture, such as bunks and chairs, shall be conductive to minimize the possibility of accumulation of a static electrical charge. Bare aluminum is conductive; however, most aluminum that is to be handled is anodized. This anodized finish is highly insulating and blocks the desired electrical discharge path. In this case, provisions should be made to ground furniture.

b. If aluminum paint is used inside a DSS, precautions shall be taken to ensure that it is not applied over rusted steel. A primer, not containing red lead or iron oxide, shall be used under the aluminum paint.

c. Magnesium and alloys containing significant amounts of magnesium shall not be used in the DSS because of their high combustibility.

B.8 FABRICATION

The fabrication and testing techniques to be employed during the manufacture of a DSS shall be considered in the design process to ensure that the system can be fabricated and tested as designed.

B.8.1 Fabrication, Welding and Brazing

All fabrication, welding and brazing shall be performed in accordance with written procedures. NDT acceptance criteria for welded/brazed joints and welder/brazer qualification must be included in these procedures. The procedures shall be approved by the Program Manager with SCA concurrence.

B.8.2 Threaded Fasteners

The design of all threaded fasteners, including bolts, studs, cap screws, and nuts, should meet the requirements of FED-STD-H28, Screw-Thread Standards for Federal Services. Thread protrusion shall be in accordance with the requirements of NAVSEA 0902-018-2010, General Overhaul Specifications for Deep Diving SSBN/SSN Submarines, Section 9090-3-d. When special fasteners are required which do not conform to the above criteria, Program Manager approval is required on a case basis.

B.8.3 Locking Devices for Mechanical Fasteners

A need for locking devices on mechanical fasteners shall be evaluated by the Program Manager. A locking device that meets the following functional requirements is generally considered satisfactory.

a. It provides a positive locking action.

b. It is relatively simple to install.

c. The design lends itself to inspection that will ensure proper installation without disturbing the locking feature.

If the Design Agent selects locking devices that do not meet the above criteria, such as blind hardware, he shall furnish sufficient information to justify the safety and integrity of the connection under the service conditions. The justification shall include recommended inspection procedures and acceptance standards.

If locking devices are not practical, critical fasteners should be marked with a "torque stripe" which identifies relative location of parts when properly torqued for ease of inspection. For further design guidance information on fastening devices refer to NAVSEA S9505-AM-GYD-010, Submarine Fastening Criteria (Non-Nuclear).

B.8.4 Protective Finishes

Finishes applied to pressure-containing elements shall not be of a type likely to permit the development of hidden pitting. Metal applied as a surface finish, coating, or cladding shall be lower on the electrochemical scale than the metal to which it is applied. The use of dissimilar metals, as defined by MIL-STD-889 (Dissimilar Metals), in these applications shall be justified by the Program Manager as not presenting an unacceptable corrosion, toxic or flammability hazard.

B.9 NAVAL ARCHITECTURE DESIGN

The naval architectural requirements that the Program Manager shall consider as a minimum are: static and dynamic stability, both transverse and longitudinal; the conditions of list and trim; the strength of the DSS; and the dynamic consideration of stability and motion of the DSS in a seaway.

B.9.1 Stability and Equilibrium

The Program Manager shall demonstrate, where applicable, both by calculation and by tests, that a DSS has adequate static and dynamic stability under the various loadings and conditions encompassed by the design (e.g., surfaced, submerged, and all possible emergency surfacing conditions). Any limiting conditions for sea state,

winds, temperatures, water density variations, and so forth, must be identified. Extreme loading conditions and the resulting stability shall also be analyzed. For example, some DSSs jettison relatively large weights to achieve buoyancy in an emergency. There is an attendant risk that significant weights might be jettisoned inadvertently while performing normal operations. The Program Manager must show that the safety of DSS personnel would not be jeopardized under these conditions. Detailed information on the criteria for stability and reserve buoyancy must be furnished to operating personnel to permit proper control of loading and to avoid danger of capsizing or foundering in heavy seas or swells. The Program Manager shall also demonstrate that the DSS is adequate to withstand such factors as wave slap and that the strength of the structure of the DSS is adequate in the surfaced condition. Protection shall be provided against foundering.

a. If the DSS is manned while being handled it must remain stable while being removed from the sea to its cradled position aboard ship or on another platform. The Program Manager must demonstrate that the DSS and its handling system are capable of passing through the sea/air interface without damage to the DSS or its occupants.

b. The Program Manager shall identify the systems and components that provide any necessary stability and buoyancy for the DSS under operating conditions. A failure analysis will be provided by the Program Manager to address the consequences of a failure or loss of displacement by any of the systems and buoyancy components. The adequacy of specific materials must be justified as discussed in Appendix A.

c. Some DSSs (e.g., DSRVs, tethered submersibles, etc.) are operated while either permanently or temporarily mounted on a surface platform. In these cases, the surface platform shall provide sufficient stability so that the divers or occupants, while in the water, shall not be endangered because support personnel on the surface are unable to provide vital functions in a seaway.

d. The Program Manager must show that the structural strength of the DSS in a seaway does not endanger the safety of personnel. A DSS may also operate in close proximity to the ocean bottom. This means that there will be a hazard of striking objects, grounding, or even deliberate bottoming. There is also the hazard of bumping against or colliding with the surface support ship. The Program Manager must show that a DSS can withstand such incidents or demonstrate that sufficient precautions can be taken to avoid such situations.

B.9.1.1 Inclining Experiments and Trim Dives for Submersibles and Submerged Habitats

If the DSS is of such complex geometry that reliable curves of form cannot be readily calculated, then air, surface, and submerged inclining experiments must be performed. When the curves of form, or the precalculated form characteristics are available, only the surface and submerged inclining experiments are required. If the

DSS vessel is not too large, the longitudinal trimming moment can be determined by direct measurement or by a longitudinal inclining experiment. In addition, a trim dive is necessary to determine the proper weight and location of ballast, both permanent and variable, that will permit the vessel to operate under the design conditions of loading and in water of any density. The Program Manager shall submit the inclining experiment and the trim dive results with the evaluation of the stability of the vessel.

B.9.2 Additional Conditions

The Program Manager must demonstrate the adequacy of all unique conditions of the candidate DSS. Any unique condition, such as mating a DSS to a deck decompression chamber, must be capable of being performed under all sea state conditions specified by the Program Manager without endangering the embarked personnel.

If the DSS is to be secured to a host ship or other platform it must be designed to have adequate attachment capability to withstand the sea state conditions specified by the Program Manager.

B.10 DESIGN OF PIPING SYSTEMS

Piping systems shall be designed to withstand, without failure, all anticipated service and test loadings such as:

a. Weight of pipe fittings, valves, and contained fluid (including hydrostatic test fluid).

b. Internal and/or external pressure, both static and cyclic.

c. Deflections and rotations of structure and equipment when they can be transferred to the piping.

d. Restraint of hangers and supports.

e. Thermal expansion/contractions and transients.

f. Internal and external dynamic loads such as vibration and shock.

g. The mechanical loads caused by operation of the system.

h. Pressure transients caused by operation of the system.

For a DSS which can be pressurized, piping which, if ruptured, would depressurize the DSS shall be protected against damage by suitable routing or shielding. Connectors should be designed and arranged so that it is physically impossible to

connect a system of one pressure level to one of another pressure level. If gas reservoirs such as flasks and cylinders are included in a system, a readily accessible valve will be provided to stop gas flow from the storage source. The valve must be able to withstand full pressure plus an adequate design margin.

Piping and tubing shall not be used as support for heavy components such as regular line valves, relief valves, check valves, strainers and filters. One pipe line shall not be used to support another. Block-type hangers may be used to support two or more pipe lines with the assembly-type hangers attached to suitable structural members.

Arrangement, selection and design of pipe hangers should be carefully considered as a basic element of the piping system design.

The number of pipe joints shall be kept to a minimum and be accessible for inspection. The Program Manager must justify the selection of the type of joint used. The justification must include such information as previous similar service experience, recognized standards and specifications, NDT, and developmental testing.

B.10.1 Piping System Flexibility

Piping shall be designed to have sufficient system flexibility to prevent premature failures and/or prevent:

a. Overstressing of the piping.

b. Leakage of mechanical joints.

c. Excessive forces and moments translated to connected equipment and structures which exceeds the limits specified or allowed for them or renders them inoperable.

The structural adequacy of the piping system will be demonstrated by the Program Manager for all anticipated service loadings. In addition, the Program Manager shall show that the fatigue life of the piping system is adequate by performing a fatigue analysis as outlined herein.

It is desirable that piping flexibility calculations be performed by the Program Manager as a measure of assurance of adequate stress levels prior to material certification. Detailed sketches of piping under examination may be submitted with calculations as part of the calculation report. Calculations should show maximum stresses and their location in each section of piping under examination. Calculations should be submitted in a detailed form that will permit their review without difficulty and shall include a statement delineating the following:

- Theoretical basis of calculations

- Method of performing calculations

- Simplifying assumptions

- Sign conventions

- Assumed material and dimensional data

- Fatigue reduction factors

- Stress intensification factors

- Allowable system stress range

- Other pertinent information such as deflections of anchor and support points.

The piping flexibility analysis shall consider the added flexibility of piping components. Flexibility factors shall be in accordance with the ASME B31.1 (Power Piping) code for pressure piping. Piping components for which there are no flexibility factors listed in ASME B31.1 shall be considered rigid unless the Program Manager can justify the use of added flexibility. The Program Manager's piping flexibility analysis will include calculations of the bending moments, twisting moments, and reaction forces imposed on each critical component in the piping system. Flexibility analysis is not required for pipe NPS 3/8 inch and smaller or for tubing 1/2 inch diameter and smaller, but piping and tubing of these sizes shall be arranged such that relative deflections of anchor, restraint or header attachment points will not cause excessive stress.

All lines must be identified and labeled to indicate function, content, and direction of flow, according to a recognized government standard (e.g., NAVSEA S9086-RK-STM-010/CH-505, Naval Ship’s Technical Manual Chapter 505, Piping Systems).

All components that are used for the transmission of breathing gases within a DSS shall be marked with an approved color code and a word or letter symbol to identify the specific gas contained and the primary hazard involved. The color coding of MIL-STD-101, Color Code for Pipelines and for Compressed Gas Cylinders is recommended for DSS design.

B.10.2 Piping Systems Component Structural Design Consideration

It is desirable that the Program Manager perform a stress analysis of each piping system component. This analysis shall consider all anticipated loading conditions including the loads calculated in the piping flexibility analysis discussed above. Applicable requirements are given below.

The structural design requirements used for externally pressurized components shall not be less than the requirements for the pressure hull and hard structure.

For internally pressurized components of Category 1 and 2 materials, the following structural design basis shall be used:

a. The allowable operating stress, S_m, for ferrous materials should be taken as the lesser of two-thirds of the minimum specified yield strength or one-third of the minimum specified tensile strength. For nonferrous materials, S_m should be the lesser of two-thirds of the minimum yield strength or one-fourth of the minimum specified tensile strength.

b. General membrane stress should not exceed S_m.

c. Local membrane stress must not exceed 1.5 S_m.

d. The highest value of combination of membrane stress and primary bending stress must not exceed 1.5 S_m.

e. The highest valued combination of primary and secondary stresses must not exceed 3 S_m.

f. Peak stresses, including effects of local stress concentrations, must be limited by fatigue considerations, as discussed in Section B.2.

g. Consideration of the following should be included in the analysis:

(1) Erosion/corrosion allowances

(2) Mechanical strength to accommodate fabrication processes

(3) Item identification marking (vibro-etch, etc.)

(4) Redundancy, safety features, remote and emergency operation.

B.10.2.1 Categories of Stress

The categories of stress referenced to above are defined as follows:

a. Primary stress. A primary stress is one which is required to produce a state of equilibrium with the applied loads. The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses are further classified as follows:

(1) General membrane stress. Average value of stress across a solid cross section, excluding discontinuities and stress concentrations.

(2) Local membrane stress. Average stress across any thickness at a particular location on the pressurized component. This includes the effect of discontinuities but not stress concentrations. Also, it is limited in extent to a relatively small area of the component.

(3) Bending stress. A stress at a particular location on the component which is proportional to the applied or induced moments and is proportional to distance from the centroid of the section. The effects of discontinuities and concentrations are excluded.

b. Secondary stress. A stress which is developed by constraint of adjacent parts of the component and is not required to produce equilibrium with the applied loads. Secondary stresses are self-relieving in nature and are necessary to satisfy continuity of the structure.

c. Peak stress. The maximum combined stress at any point in the structure. The peak stress at a given point will be the maximum combined primary and the secondary stresses suitably increased to account for local stress concentrations. The basic characteristic of a peak stress is that it does not cause any noticeable distortion and is of concern primarily as a possible source of a fatigue crack growth or brittle fracture.

For components whose geometry is not amenable to analytical evaluation, and when considered appropriate by the Program Manager and SCA, the structural adequacy of piping system components may be verified experimentally. In this case, an experimental stress analysis and burst test such as specified in the ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, Appendix 6, may be performed in lieu of an analytical stress analysis. This approach should be detailed and approved prior to use as an acceptance method.

For components constructed of Category 3 material, the Program Manager is not required to use the structural design basis outlined above. However, as in the case of pressure hulls constructed of Category 3 material, the Program Manager must show that the design basis used is at least as inclusive and conservative as the basis discussed above. Further, the structural adequacy of components constructed of Category 3 material must be verified by tests of full-scale prototype components.

B.10.3 Design of Piping Systems and Components

All piping components shall be designed or selected to meet the maximum flow that is required for the mission conditions expected for the DSS. These conditions shall be specified when justifying the design or selection.

a. All manually operated piping components shall be readily accessible and easily operated under normal and emergency conditions.

b. Unless directed otherwise, pressure-reducing valves shall be provided with inlet and outlet isolation valves, and a valve with associated piping which allows bypassing flow when the pressure-reducing valve inlet and outlet isolation valves are shut. The flow capacity of the pressure-reducing valve bypass shall be no greater than the flow capacity of the downstream relief valve. The piping from the outlet of the pressure-reducing valve downstream to and including the outlet isolation valve shall be designed and tested to the pressure at the inlet of the pressure-reducing valve.

A bypass shall be provided in any system where the ability to maintain uninterrupted service is required. All particulate filters shall be installed so that a clogged filter can be bypassed without disrupting the fluid or air flow to the end-use point. The bypass can be either internal or external to the filter.

A check valve or "nonreturn" valve is required in any system where two-way flow is possible but one-way flow is required for the safety of the DSS personnel or for normal operation of the equipment.

Flareless, mechanical friction, compression or bite-type connections will not be used on piping components whose failure could cause uncontrolled depressurization or flooding of pressure vessels, life support systems, ballast tanks, electrical assemblies or other life-critical components. The use of such connections in control and monitoring systems may be permitted on a case basis.

Lines which are routinely disconnected must be provided with suitable closure devices for each exposed connection to prevent entrance of foreign materials and debris when the system pressure boundary is broken. Routine disconnections are those associated with inspections, overhauls, and the normal DSS setup, operation and takedown. Both male and female connections shall be so protected. Caps that introduce moisture and tapes that leave adhesive deposits shall not be used for this purpose. When not in use, closure devices should be stored in a way that prevents contamination.

B.10.4 Hoses and Umbilical (Deck Shelters, Etc.)

For specific information on diver umbilicals refer to the U.S. Navy Diving Manual, NAVSEA 0994-LP-001-9110 (Volume 1) and NAVSEA 0994-LP-001-9020 (Volume 2). For specific information on piping system installed flexible hoses refer to NAVSEA S6430-AE-TED-010 (Volume 1), Technical Directive for Piping Devices, Flexible Hose Assemblies.

B.10.5 Special Considerations for Oxygen Systems

Oxygen is a stable, nonflammable liquid or gas. However, use of oxygen involves a degree of risk. Oxygen is a strong oxidizer that vigorously supports combustion. As the concentration, pressure and temperature increases, so does its reactivity. All rubber and plastic can burn in 100 percent oxygen at atmospheric pressure, while many metals burn in pressurized oxygen. Further complicating the issue is the use of oxygen for life support, the inherent confined space of the DSS, and its dense packaging. The Program Manager shall be responsible for consideration and analysis of any special conditions, due to the use of oxygen in the specific DSS design, that may affect the safety of DSS personnel.

a. Oxygen quality shall meet the requirements of Appendix F.

b. Oxygen systems shall be designed to limit rapid pressurization, limit velocity, limit high pressure piping and components, limit mechanical joints, limit impingement paths, and control particle generation in accordance with accepted practices such as ASTM G88, Standard Guide for Designing Systems for Oxygen Service.

c. High pressure portions of the oxygen system shall be welded wherever possible for maximum integrity. Where mechanical joints are used in oxygen systems, the ability to isolate a leak shall be evaluated. If the leak can result in developing an oxygen enriched atmosphere in a space not designed for that service, action shall be taken to mitigate the hazard by welding affected joints, locating isolation valves for rapid access or other appropriate method. Additionally, confined spaces with oxygen systems having mechanical joints shall be evaluated for fire hazard to surrounding material in the event of a leak. Oxygen system mechanical joints should not be located where leakage or failure could easily ignite surrounding material. Examples include locating oxygen mechanical joints next to a hydraulic system or next to electrical components with heated surfaces. Where the arrangement cannot eliminate all reasonable hazards, and the joint cannot be moved, flame shields or other appropriate method should be used.

d. Metallic materials wetted by oxygen shall not propagate a flame, shall not burn, and shall be impact resistant with oxygen at the maximum operating pressure of the system in accordance with ASTM G94, Standard Guide for Evaluating Metals for Oxygen Service.

e. Non-metallic material wetted by oxygen shall be resistant to auto-ignition, shall be resistant to impact ignition, and shall have the lowest possible heat of combustion in accordance with ASTM G63, Standard Guide for Evaluating Non-metallic Materials for Oxygen Service. Additionally, where non-metallic material is installed, the design shall minimize the surface area and volume exposed to oxygen.

B.10.6 Piping System Design Verification

Pressure testing of DSS piping systems shall be in accordance with Appendix J.

B.10.7 Relief Valves

Pressure-relief valves that are required in the system design and installed on man-rated DSSs must not present a hazard to the operator or occupant by causing rapid compression/decompression due to system malfunction or extreme pressure during DSS testing or operation. Discharge from relief valves shall be directed away from operator(s), occupant(s) and equipment. Burst disc designs shall not be used or installed on man-rated systems, with the exception of portable flasks.

B.11 DESIGN OF ELECTRICAL SYSTEMS

Consideration must be given to the electrical requirements for the DSS and supporting equipment. This covers a wide range of equipment from heavy machinery such as pumps, compressors, and handling equipment, to precise instrumentation for control, communication, and data acquisition.

When exposed to the high oxygen concentrations of many DSSs, electrical equipment inside the DSS pressure hull has proved hazardous to personnel. The use of electrical equipment with history of or demonstrated potential for arcing or electrostatic discharge during normal operation is prohibited. A safety hazard analysis shall address these areas.

B.11.1 Power Requirements

The Program Manager must provide an estimate of the power requirements to support the DSS. The Program Manager shall show how much power is required from the support ship/facility and how much of the DSS is self-supporting. Further, the Program Manager will identify normal power requirements and emergency power requirements.

B.11.1.1 Batteries

The ABS Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities, Section 11 provides the guidelines and requirements that must be considered and taken under advisement during design and specification development for DSS batteries.

B.11.2 Wiring Methods

Cable subject to deep submergence pressure shall be environmentally acceptable and be technically justified for its intended application. If the cable is not military

specification, a cable specification sheet must be provided. Cable runs shall be selected so that the effect of any fire damage due to a fault will be minimized with respect to damaging other cabling in the distribution system. Cable and wire housed inboard shall be arranged or protected from personnel movement within the DSS. During DSS construction, installed cables shall be protected against mechanical damage, burning by welders' torches, and contact with oils and solvents. All cables terminating in pressure-type connectors shall have connectors applied in such a manner as to exclude all voids from the cable-connector assembly and to impose no undue mechanical stresses that restrict cable flexing during DSS transport and operations. A means of support shall be provided at the cable/plug interface to minimize bending during DSS operation. All outboard cables shall be pressure tested and the IR checked. The IR should be equal to or greater than 10 megohms for new cable and 1 megohm for existing cable when corrected for 70°F. In rare cases, the length of the cable may be sufficiently long to preclude these readings. In that case, an acceptable IR can be derived using manufacturer's data and submitted to NAVSEA for approval.

a. Cables shall be protected against damage from accidental contact, crushing, shearing, or use as a handhold. Cables exposed to seawater shall be non-wicking and shall be capable of withstanding 1.5 times the maximum pressure to which the cable will be exposed in service. The hydrostatic test for cable exposed to seawater is:

(1) 0 to 100 psig - hold for five minutes at 100 psig, cycle three times.

(2) 0 to 1.5 times maximum operating pressure - hold for one hour, cycle one time.

b. Conductors shall be flexible and easy to handle. Sufficient slack shall be left in the conductor at penetrators to permit plug-in and disconnect operations without excessively stressing the cable. Conductors should be supported, where possible.

c. Particular care should be taken in the case of portable electrical equipment to protect conductors from excessive flexure, kinking, tension, being caught between movable objects, or being stepped on. Conductors shall be resistant to such abuse.

d. Conductors within cables shall be electrically insulated from each other, from the DSS, and from the operators and occupants.

e. Conventional switches, outlets, and other wiring devices are prohibited inside the DSS. Devices used inside the DSS shall be intrinsically safe, qualified by Underwriters Laboratories (UL) or other technical agencies, and technically justified for their intended application.

B.11.3 Ungrounded System

All electrical power distribution circuits shall be supplied from an ungrounded electrical system fed from isolation transformers to minimize electrical shock hazard and ensure continuity of service. All equipment designed to employ chassis grounds as part of the electrical circuitry must be isolated from the electric power system by a transformer or suitable isolation device achieving isolation from DSS structure and personnel.

B.11.4 Fault Current Protection

Fault current protection devices will be provided for each unit of electric generating equipment and for each unit of power consuming equipment connected to the distribution system. Each current carrying conductor shall be electrically protected. The devices shall be adequate for the environment, proof tested, and technically justified for their intended application. Fuses and thermal fault current protective devices are prohibited in helium-oxygen environments. Fault current protective devices of magnetic design must be utilized in a helium-oxygen environment. Fuses and thermal fault current devices are unacceptable in compensating systems utilizing insulating oils unless adequately sealed from exposure to oil.

B.11.5 Electrical Shock Hazards

All electrically powered equipment and/or electrical equipment enclosures shall be adequately grounded to prevent shock hazards to personnel. For guidance see MIL-STD-1310 (Standard Practice for Shipboard Bonding, Grounding, and other Techniques for Electromagnetic Compatibility and Safety), and Code of Practice for Safe Use of Electricity Under Water, dated September 1985, issued by the Association of Offshore Diving Contractors.

The environment for electrical components (e.g., cabling, connectors, protective devices, motors, power supplies) that are used on DSSs may differ markedly from normal shipboard conditions. The components may be oil-immersed, subject to full sea pressure, operate at low temperatures, or be subject to high vibration and high humidity. The Program Manager shall furnish specific test information which justifies the ability of the electrical component to function in the intended environment for its design life. For flammability and toxicity considerations, see Section B.7.

Materials used in electrical equipment must be shown, by test and/or experience, to be resistant to deterioration by the in-service operating environment.

All DSSs shall have the capability to measure system IRs during operations.

B.11.6 Insulation Considerations

Electrical insulating materials shall be selected on the basis of their ability to insulate the DSS equipment and to provide the proper functional and mechanical characteristics. Electrical insulating materials shall be nonflammable and nontoxic (see MIL-E-917 and/or the applicable volume of the Deep Ocean Technology program Handbook for guidance). Examples of electrical functional characteristics are dielectric strength, IR, and arc resistance. Mechanical characteristics include impact strength, tensile strength, elongation, flexibility, and adhesion and abrasion resistance. Teflon-coated wire or kapton polymide film over FEP-type insulation is generally preferred for DSS applications.

B.11.7 Electrical Connectors and Penetrators

B.11.7.1 Electrical Connectors

Connector design shall permit the DSS operator or diver to readily disconnect the umbilical and any other electrical conductor without receiving an electrical shock. System design/operating procedures shall normally preclude disconnecting connectors when the circuit is energized. Electrical connectors shall be sealed against water intrusion at maximum operating pressure.

a. All cables terminating in pressure-type connectors must have connectors applied in such a manner as to exclude all voids from the cable-connectors assembly and to impose no undue mechanical stresses on conductors or connectors.

b. The materials and methods used to join connectors and fittings to umbilical cables and hoses shall provide a strong bond capable of withstanding severe handling and operating conditions. Connector pins and sockets must be of corrosion resistant material or plated to prevent corrosion and electrical discontinuities.

c. Electrical connectors must be designed to prevent incorrect connection. This may be accomplished by size selection, key fit, or other means. Color coding or other visual identification alone is insufficient unless specifically authorized by the Program Manager for individual connections. Electrical connectors shall be designed to prevent accidental disconnection.

B.11.7.2 Electrical Penetrators

a. Electrical cable pressure vessel penetrators must provide high pressure water barriers at the hull to prevent flooding of the DSS in the event of external cable failure. Pin-type connections for cable entrances into compensated enclosures are preferred; however, terminal tube entrances are acceptable provided evidence of compatibility of the cable jacket and insulation with the compensating medium is provided.

b. Since the electrical hull penetrator (EHP) is part of the primary pressure boundary, data shall be provided to ensure that its hydrocyclic life is defined in relation to the design life of the hull and thermal shock to connector.

B.11.7.3 Electrical Hull Penetrator Protection

Since the EHP is part of the primary pressure boundary, circuits incorporating EHPs in their design must include some device(s) to protect the penetrator from damage in the event of a casualty, such as a penetrator connector flooding.

a. Protective devices shall be provided which protect the penetrator pins/contacts from damage due to excessive currents. The Program Manager must demonstrate the ability of these devices to protect the EHP.

b. As part of the electrical system design, a failure analysis report shall be provided demonstrating the effectiveness of the EHP protective device(s).

B.11.8 Lighting Systems

DSSs shall be equipped with normal and emergency lighting systems. Auxiliary portable lighting shall be provided for operators in all manned spaces and shall be located in the immediate vicinity of critical controls in those spaces.

When lights are installed inside a hyperbaric DSS, the housing of the light must be adequately designed so as not to explode or implode, and the wiring to the fixture must be installed so as not to create a fire or shock hazard. The fixture and wiring must be sufficiently rugged to be able to withstand inadvertent impact and mechanical loads without causing a fire or shock hazard.

B.11.9 Instrumentation

Instrumentation must be electrically isolated from the DSS personnel, but not located in a manner that might subject it to erroneous readout. Electrical failure of one instrumentation device must not impair the use of another. All instrumentation must be compatible with its intended environment and must not create a fire, electrical, or toxic hazard.

B.11.10 Communication Systems

In all operating conditions of a DSS, there shall be a primary and a back-up communication system. The back-up communication systems between operator stations will provide redundancy in all modes of operation. The systems will be designed such that they operate independent of each other and the failure of one system shall not impair the use of, or result in the loss of the other. The electronic

communication system may be supplemented as necessary by visual communication systems, such as lights and message boards. The Program Manager shall specify the distance and water conditions for which these systems are appropriate.

Other communication systems which may be installed in a DSS include helium speech unscramblers, and through-water communicators. All equipment must be compatible with the environment and must not create a fire, electrical or toxic hazard.

B.11.11 Heating Systems

All electrical heating equipment must be compatible with the environment and must not create a fire, electrical or toxic hazard.

B.12 PROPULSION SYSTEM

If the DSS propulsion system is in the SOC as being required for surfacing the DSS, the Program Manager shall provide a propulsion system capable of performing for the maximum mission duration.

Adequate redundancy will be provided so that in the event of the primary propulsion system failure, the DSS can return to the surface or submerged base. The system shall perform without excessive noise, vibration, toxic off-gassing or creating other dangers to DSS personnel. The Program Manager shall provide full documentation of the propulsion system design attributes, within the SOC, to the SCA for review and approval.

B.13 HUMAN ENGINEERING

The DSS Design Agent shall consider human engineering in the design (see MIL-STD-1472 for guidance). Particular attention should be given to accessibility of equipment and controls by the DSS operator. Personnel positioning shall be considered to minimize discomfort and permit adequate visual and physical identification of controls and equipment under emergency conditions.

B.13.1 Sound Levels

For pressurized diving situations exposures of eight hours or less, the levels established by NAVMEDCOMINST 6260.5, Occupational Noise Control and Hearing Conservation, shall be met. For exposures exceeding eight hours per day, as in saturation diving, an interim allowable noise exposure level has been established by the Bureau of Medicine and Surgery.

The maximum allowable sound pressure levels (SPL) in decibels (dB) for steady-state background noise shall be less than 84 dB.

The maximum allowable SPL for intermittent peak noise exposure instances not exceeding 15 minutes duration (compression, decompression, and ventilating noise) are as follows:

Daily Number of Exposures	Maximum Allowable SPL
1	104 dB
2	100 dB
4	96 dB

Variations to this table shall be based on more detailed information and consultation with cognizant NAVMED personnel.

B.13.2 Thermal Control

Based on an assessment of the mission requirements, NAVSEA may require a heating system to maintain the comfort, performance and safety of DSS personnel. For additional information see NAVSEA 0994-LP-001-9110 (Volume 1) and NAVSEA 0994-LP-001-9020 (Volume 2).

B.14 LIFE SUPPORT SYSTEM

The DSS life support system shall provide a breathable atmosphere to all occupants during all normal and emergency design operating conditions. Normal operational requirements shall be as specified by the appropriate platform or vehicle top level requirement. Emergency operational requirements specified in the platform or vehicle top level requirement shall address, when applicable, the following attributes.

a. Toxic Atmosphere. For all platforms and vehicles, emergency life support shall sustain all occupants for 150 percent of the time necessary to safely surface the platform or vehicle from its maximum operating pressure or depth; return the platform or vehicle to a submerged host; or ventilate the vehicle, platform, or compartment of toxic contaminants. The Program Manager and SCA shall approve the duration of emergency life support for toxic atmosphere.

b. Fouled Vehicle. For untethered vehicles (other than nuclear submarines), sufficient emergency life support shall be provided to sustain all occupants for not less than 72 hours, unless otherwise approved by the Program Manager and SCA. For tethered vehicles or platforms, emergency life support shall be provided to sustain all occupants for not less than 36 hours, unless otherwise approved by the Program Manager and SCA.

c. Decompression (if considered an emergency evolution). The appropriate worst-case decompression table, number of personnel to be treated, and number of tenders shall be specified.

B.14.1 Life Support System Design Specification

The Program Manager shall develop a design specification for the life support system. The design specification shall address the life support system's capability to support all required services consistent with the normal and emergency operational design requirements of the DSS.

The design specification shall indicate whether the life support system is a closed and/or open circuit process. Closed circuit life support systems are used in confined spaces to recycle breathing gas. Closed circuit life support systems are generally distinguished by the use of separate oxygen systems and carbon dioxide removal equipment. Open circuit life support systems are often used in surface or host ship supplied ventilated diving chambers that use fresh breathing gas to provide oxygen to the occupants and remove carbon dioxide from the space. Combinations of open and closed circuit life support systems are sometimes used.

B.14.1.1 Closed Circuit Life Support Design Specification

The design specification for closed circuit, life support systems shall specify the following:

a. Oxygen metabolic rates for each expected human activity (see Appendix E).

b. Carbon dioxide respiratory quotient for expected human activity (see Appendix E).

c. Oxygen control: percent and/or partial pressure; and the range of control.

d. Normal mission duration man-hours at each metabolic activity level based on maximum design occupancy.

e. Emergency duration man-hours (for each event) at each metabolic activity level based on maximum design occupancy.

f. The maximum compartment pressure, and the number of times the compartment will be pressurized.

g. Type and purity of each breathing gas (see Appendix F). Where the normal ambient environment or normal operating requirement will introduce or allow build-up of contaminants to unacceptable levels, appropriate purification equipment (in addition to carbon dioxide removal) shall be specified (see Appendix F).

h. Design margins that will be applied for oxygen bank sizing, carbon dioxide removal equipment sizing and/or load-out, and gas banks (and/or compressors) used for compartment pressurization.

i. The allowable range for temperature and humidity.

B.14.1.2 Open Circuit Life Support Design Specification

The design specification for open circuit, life support systems shall specify the following:

a. Breathing gas ventilation rates for each expected metabolic activity level (see Appendix E).

b. Type and purity of each breathing gas (see Appendix F). If breathing gas is obtained from an environment that differs from standard atmospheric conditions, appropriate purification equipment, such as carbon dioxide removal, shall be specified (see Appendix F).

c. Normal mission duration man-hours at each metabolic activity level based on maximum design occupancy.

d. Emergency duration man-hours (for each applicable event) at each metabolic activity level based on maximum design occupancy.

e. The maximum compartment pressure, and the number of times the compartment will be pressurized.

f. Design margins that will be applied for all breathing gas banks (and/or compressors) used for ventilation (both compartment and personnel) and pressurization. If carbon dioxide removal equipment is required, suitable design margin shall be specified.

g. The allowable range for temperature and humidity.

B.14.2 Breathing Gas System General Design Considerations

Life support systems supplying breathing gas shall be designed for ease of operation and maximum reliability. The Program Manager shall furnish data on actual operating characteristics obtained by test. Additionally, the Program Manager shall furnish data on the reliability of the life support system. The reliability data may be based on either previous history of use or on the results of life cycle test data.

a. Breathing gas purity shall be in accordance with Appendix F. Special requirements, which may be necessary because of the composition of the various

breathing gases must be established independently for each situation. However, where multiple gas sources are used, adequate labeling and procedures shall be provided to prevent inadvertent use an incorrect breathing gas or gas mixture.

b. All breathing gas systems shall be cleaned in accordance with Appendix G.

c. All breathing gas systems shall be verified free of unacceptable gaseous contaminants in accordance with Appendix F.

d. When oxygen level is controlled in percent by volume, the normal range should be 18 percent to 21 percent to support normal respiration and minimize fire hazard. The oxygen low level alarm should be at 17 percent and oxygen high level alarm should be at 23 percent.

e. When oxygen level is controlled by partial pressure, the range shall not result in oxygen toxicity or a fire hazard. The reader is advised that during ascent, compartments under partial pressure control may require oxygen flow rates much higher than those required for metabolic make-up to prevent an oxygen deficient atmosphere. The Program Manager and SCA shall verify that oxygen systems supporting partial pressure oxygen control are designed to support both metabolic make-up and the maximum ascent rate of the associated compartment or equipment.

f. Normal breathing gas systems using open circuit designs that do not incorporate separate emergency breathing systems shall have not less than two independent sources of breathing gas; one of which must be from a stored gas supply. For these designs, acceptable configurations are either two stored breathing gas sources or one breathing gas compressor(s) and one stored gas supply. Special consideration shall be given to open circuit, life support systems operating near or at sea level. During this condition, ventilation exhaust pipe sizing must be sufficient to support required ventilation flow rate without pressurizing the DSS.

g. Life support systems with closed circuit normal breathing designs shall include an emergency breathing system.

h. Emergency breathing systems shall be capable of operating separate and distinct from other breathing systems. However, the emergency breathing system can cross-connect with the normal breathing system provided suitably lock-shut isolation valves or other devices are installed to prevent inadvertent operation. Emergency breathing systems can be open or closed circuit, but shall only be supplied by a stored gas source. All materials used in emergency breathing systems shall be fire and heat resistant or their use justified. Emergency breathing systems shall provide acceptable breathing resistance (inhalation/exhalation) and comfort under all operating conditions. Special consideration shall be given to closed circuit emergency breathing system operating in pressurized environments since breathing resistance will increase significantly with depth.

i. The instantaneous release of the stored gas in the largest single container, which cannot be isolated from the DSS, shall not result in a pressure release or gas mixture concentration that would pose an immediate danger to the DSS personnel.

j. Instrumentation shall be provided to monitor the performance of normal and emergency breathing gas systems and warn operators and passengers of unsafe conditions. Suitable redundancy of instrumentation shall be provided and be capable of operating in the event of normal power failure.

k. Breathing gas supply lines from component to component in the DSS should be constructed of rigid tubing where possible. Flexible hose may be used to carry the breathing gas to movable components or flexibly mounted components. The Program Manager shall demonstrate that each flexible hose exhibits adequate strength, material compatibility with the breathing gas mixture, and cleanliness. Flexible hoses shall meet the pressure test requirements stated in NAVSEA S6430-AE-TED-010 (Volume 1). Where possible, normal and emergency breathing gas supply lines should be arranged separate from each other, and away from possible ignition or contamination sources.

B.14.3 Breathing Gas Equipment Considerations

Considerations for breathing gas compressors, gas storage containers, relief valves, carbon dioxide removal equipment and instrumentation are discussed as follows:

B.14.3.1 Breathing Gas Compressors

When the normal breathing gas system includes a compressor that will be used to supply breathing gas, the following elements shall be considered in the design of the compressor:

a. The compressor shall provide sufficient breathing gas to support 150 percent of the greatest breathing demand.

b. The compressed gas produced by the compressor will retain all the contaminants contained in the atmosphere from which it is taken. Consideration must be given to the location of the compressor inlet due to possible contamination from machinery exhaust fumes or other atmospheric contaminants.

c. Output flow, output pressure, output temperature, compressor lubricants, reliability, and maintenance requirements are the primary considerations in the selection of a compressor for breathing gas. For diving systems, the reader is directed to NAVSEA 0994-LP-001-9110 (Volume 1), NAVSEA 0994-LP-001-9020 (Volume 2), and NAVSEAINST 10560.2 (Diving Equipment Authorized for U.S. Navy Use), the Approved for Navy Use (ANU) list of acceptable diving compressors. Breathing gas compressors shall incorporate cooling to reduce output gas to a breathable temperature.

d. Suitable filtration shall be installed to remove particulate, moisture, oil mist and gaseous contamination if warranted by the compressor design or compressor inlet conditions. For diving systems, the reader is directed to NAVSEAINST 10560.2, the ANU list of acceptable diving compressor particulate, oil mist and odor filters and moisture separators. The Program Manager shall approve all other filters. Note that oil-bath filters shall not be used in any breathing systems.

e. High pressure air compressors should be equipped with a back-pressure regulator located downstream of the water/oil separator. This regulator shall be designed to maintain the maximum compressor design working pressure on all components upstream of the regulator during normal operation. This maintains proper sealing for oil-free compressors, and, for any compressor, maximizes the amount of moisture removed from the gas stream.

B.14.3.2 Stored Breathing Gas Supply

When breathing gas containers such as air, mixed-gas, and oxygen, are installed, the following items shall be considered.

a. The normal supply container(s) shall provide sufficient breathing gas for 150 percent of the longest mission for which the DSS will be used.

b. Pressure-reducing devices, designed to maintain the outlet pressure within required limits despite varying inlet pressure and varying ambient pressure, shall be provided as necessary. Regulation shall be demonstrated to be satisfactory within the design operating depths. The fail position of the regulating valve shall be evaluated for impact to system safety and reliability. All regulating valves shall incorporate a bypass valve for use in the event that the regulating valve fails. The bypass valve shall be capable of manually regulating pressure and passing the required design flow rate. Appropriate isolation valves and relief valves shall be installed, as necessary, to support maintenance and protect downstream piping and components.

c. Suitable valve protection shall be provided to prevent inadvertent depressurization of the containers. For flasks that are permanently installed and recharged in place, double valve protection shall be provided on fill lines to prevent inadvertent depressurization of the flasks.

d. Containers shall be secured to prevent their accidental detachment, and supported or restrained so that they do not impose a load on other components that are not specifically designed as supports.

e. Any breathing gas pressure control subassembly provided in the form of a variable-volume (i.e., elastomer) gas reservoir shall be:

(1) Puncture and tear resistant.

(2) Mold and fungus resistant.

(3) Configured to permit accessibility to other components.

(4) Easily removable for cleaning and airing.

(5) Resistant to collapse during normal use.

B.14.3.3 Carbon Dioxide Removal

When carbon dioxide (CO_2) removal is required, the most common method is passing ambient or expired gas through a canister containing a CO_2 absorbent material. Common CO_2 absorbent material include calcium and lithium hydroxide. These non-regenerative materials absorb carbon dioxide, releasing heat and moisture. Although theoretical efficiencies of these materials are often reported as high as 90 percent (lbs CO_2 per lb of absorbent), the reader is advised that actual installation generally average 25 percent, and rarely exceed 40 percent. Carbon dioxide absorber designs shall consider the following:

a. Carbon dioxide absorbers shall be designed and demonstrated to maintain the CO_2 content of breathing gas in accordance with the applicable DSS top level requirement (see Appendices E and F).

b. Sufficient absorbent shall be available to support 150 percent of the duration of the longest mission expected for the DSS.

c. All hydroxide-type CO_2 absorbents (such as calcium and lithium hydroxide) are caustic. Therefore, the absorber design shall ensure that particles of the absorbent are not carried to the DSS personnel in the flow of breathing gas.

d. Carbon dioxide absorbers must consider means to control moisture produced from the CO_2 absorbent reaction. This moisture may accumulate in breathing gas passages, increase resistance to the gas flow through the absorbent, and decrease the effectiveness of the absorbent. Decreased temperatures, too much water, and increased pressure reduce carbon dioxide absorbent efficiency. The design sizing shall take these effects into account.

e. Carbon dioxide absorbent canister materials shall be highly resistant to caustic attack and, if applicable, seawater corrosion.

f. Carbon dioxide absorbent canisters shall be designed for easy refilling and easy replacement. When CO_2 absorbers are used in closed circuit emergency breathing systems, and multiple canister replacements will be necessary to provide required duration, the following design items shall be considered.

(1) The emergency breathing system shall include provisions to isolate and bypass the expended absorber to allow continued use of the system.

(2) The time required to isolate, replace and restore the absorber to operation shall not result in an unsafe level of CO_2 building-up in the emergency breathing system.

g. Carbon dioxide absorber designs shall consider the following features that are greatly dependent upon canister geometry:

(1) Minimum flow resistance

(2) Maximum utilization of absorbent

(3) Maintenance of neutral buoyancy in use (as applicable) in closed-circuit or semi-closed diving rigs

(4) Reduction of gas-flow channeling that severely restricts mission duration by reducing absorbent utilization.

B.14.3.4 Breathing Gas Relief Valves

Relief valves shall be used as necessary to protect associated piping and components from overpressure. The cracking pressure, accumulation (full open) pressure, and blowdown (reseat) pressure of the relief valve shall be consistent with the system operational and design requirements. Relief valves should be operated at not less than 1 year intervals and tested not less than every three years to verify that they operate at their designated relief pressure set point (e.g., included in a planned maintenance system). Such tests shall be documented, and a metal tag stamped with the following data should be securely attached to the valve after testing:

a. System valve designation number

b. Relief pressure setting

c. Date test was performed

d. Testing activity

B.14.3.5 Instrumentation

Instrumentation for DSS life support systems shall be reliable and easy to calibrate (preferably in-place). The Program Manager shall demonstrate that the instrumentation is sufficiently accurate, and will operate satisfactorily within the range of the DSS environmental and design parameters.

a. Instrumentation requirements in a DSS will vary widely depending upon depth and exposure times. Generally, instrumentation includes all sensors, warning devices, and displays determined to be within the SOC. Instrumentation may include, but not be limited to, the following:

(1) Carbon dioxide sensors

(2) Oxygen sensors

(3) Gas source pressure indicators/sensors

(4) Gas flow sensors

(5) Electrical defect sensors (ground detectors)

(6) Respiratory gas temperature sensors

(7) Low and high level/pressure warning devices

(8) Pressure depth indicators

(9) Fire detection devices

(10) Compartment temperature sensors

(11) Compartment humidity sensors

(12) Ammeter(s) and voltmeter(s)

b. All measuring devices used shall have a back-up means for providing measurement data. Failure of one measuring device shall not impair the use of the other.

c. Electronic sensor shall be electrically isolated from the DSS personnel. Electronic life support instrumentation whose indication provides input for the decision making process by the operator or another piece of equipment shall be evaluated for at least three failure modes: out-of-range high, out-of-range low, and fail as-is. Appropriate actions (hardware or operational) shall be implemented to mitigate any hazardous effects.

d. The Program Manager and SCA shall approve oxygen and carbon dioxide sensors. Oxygen sensors shall be equipped with high-limit and low-limit alarms. Carbon dioxide sensors shall be provided with high-level alarms. Alarms should be both visual and audible where possible.

e. Normal and emergency breathing stored gas supplies shall have provisions to monitor pressure with self-powered instrumentation such as mechanical gauges, unless otherwise approved by the Program Manager and SCA.

f. Automatic transfer to reserve breathing gas supply, if provided, shall actuate a warning signal, preferably both audible and visual. Provision may be made for turning off the warning device after it has been activated. Consideration should be given to providing automatic reactivation of the warning after a specified time.

g. A check of normal and emergency system instrumentation to confirm the status (capacity and operation) of the breathing gas supply shall be required as part of the pre-dive procedure.

B.15 OPERATIONAL CONTROL SYSTEMS

An operational control system is considered to be made up of three parts. The first part, the power supply, is the source of power from which the control derives its energy. The second part, the instrumentation, is composed of the devices used to measure the variable being controlled, the devices used to measure the response of the control system, and/or the devices used to provide necessary information to determine when the control should be actuated. The third part, control actuators, is comprised of the devices which accomplish the desired control function.

The Program Manager shall furnish detailed design information for the respective control systems and components. This information must clearly discuss the capability of the system in the intended environment (e.g., temperature, pressure, humidity). Descriptions must be furnished for all control systems. In addition, the descriptions shall include an analysis of the consequence of a failure or loss of normal mode, and describe automatic and manual back-up control features available for emergency recovery or surfacing procedures. Test data in support of system and component reliability for intended service must also be provided. Design information and test data must be of sufficient detail to permit an independent evaluation of the adequacy of the controls in their environment, under all normal and emergency operating conditions.

B.15.1 Control Power Supply

Control power supplies may be manual, mechanical, pneumatic, hydraulic, or electrical. The choice shall be based on reliability in the environment in which the power supply must function. The Program Manager shall furnish information which substantiates the reliability of the power supply in the intended environment. This information may be based either on previous use of the power supply or on tests.

a. Electrical equipment must be protected against voltage variations in the power supply and against excessive flow of current when such occurrences present a hazard, direct or indirect, to the DSS or the occupants.

b. All controls deemed necessary for life support, casualty recovery or emergency surfacing must have two independent sources of power. For purposes of discussion, these alternate sources of power are to be termed normal power and emergency power. Failure of one of the power sources shall not hinder the use of the other power source. The emergency power source shall be located so that it has a high degree of survival. In instances where redundant or back-up electrical control circuits are provided to external equipment or safety devices, the circuits shall be routed through different penetrators for maximum reliability. The emergency power must have, as a minimum, sufficient capacity to permit operation of systems and instrumentation to allow the DSS to safely return from maximum operating depth/pressure to the surface condition and to maintain the DSS at the surface condition. A load analysis shall be furnished in sufficient detail to justify the power source capacity. This analysis must cover all possible combinations of power use.

B.15.2 Control Actuators

A control actuator is any device or group of devices used to accomplish a desired control function. From a certification standpoint, the basic design attributes of any control system within the SOC are reliability and fail-safe operation. To obtain reliability, the design shall be such that the control actuator is not subject to false alarms or extraneous signals which produce undesired responses. Fail-safe operation is characterized by failure modes that do not result in non-recoverable casualty situations (i.e., lethal atmospheric contamination, uncontrolled depth excursion).

a. Switches and controls that are used to manually energize a control actuator must be located so that the control actuator is not inadvertently energized.

b. Control actuators shall be designed to be fail-safe or have system redundancy; that is, failure of any portion of a control actuator shall not in any way diminish the ability of the DSS to return to the surface or base. Indication of malfunction or failure in a control actuator must be provided to the operator.

c. Individual control actuators shall be capable of being isolated from other control actuators which share a common power supply. For electrical control actuators, this requires either fuses or circuit breakers on all lines connecting the control actuator to the power supply if allowed by Section B.11.4. For hydraulic or pneumatic control actuators, this requires appropriate check valve or valve isolation on all lines connecting the power supply to the control actuator.

d. Where a control actuator operates more than one device to accomplish the desired control function, each device shall be capable of isolation from the remaining devices. The system design will be such that failure of one device does not cause

failure of the other. For electrical devices, this requires circuit protection for both supply and return lines, as well as a device that can manually disconnect the load. For hydraulic and pneumatic devices, this requires appropriate check valves or isolation valves on supply and return lines.

e. Where a control actuator normally operates automatically, provision should be made to allow the operator or diver to manually override the automatic control. The manual control shall bypass as much of the control system as is practical.

B.16 FIRE PROTECTION SYSTEM

The Program Manager must consider provisions for effectively fighting fires which may occur in the interior of a DSS. For information on fighting fires under hyperbaric conditions, refer to NAVSEA 0994-LP-001-9110 (Volume 1) and NAVSEA 0994-LP-001-9020 (Volume 2).

B.17 NAVIGATION SYSTEMS

If included within the SOC, navigation equipment shall be provided to enable the DSS operator to direct the course safely during operations. System accuracy shall be based on worst-case operating conditions. An alternate or redundant mode of navigation shall be provided.

B.18 FOOD AND WATER SUPPLY

Provisions for the storage and preparation of food and for purification and storage of drinking water shall be given consideration by the Design Agent. Information to allow evaluation of the suitability of food storage and preparation facilities, and a description of the water supply system including the cleanliness standards, purification chemicals used, and tests made to determine the solid, salt, and bacterial content of the drinking water shall be provided for review.

If there is not adequate storage facilities for food and water, the Program Manager must provide means of introducing into the DSS the supplies required to sustain the DSS personnel for the maximum mission requirement.

B.19 WASTE SYSTEMS

DSSs shall have provisions for the storage of waste products, including human metabolic wastes and wash water wastes when mission requirements dictate extended confinement.

B.20 RESCUE/RETRIEVAL SYSTEMS

The features of the rescue capabilities included in the DSS design shall be presented by the Program Manager. When specified the DSS shall be provided with the capability of being lifted for rescue when flooded. As appropriate, a specific rescue plan shall be included showing the intended means to accomplish rescue in the event of an accident while submerged. The limiting conditions for each of these operations shall be included. The Program Manager must also state whether or not the DSS is compatible with existing U.S. Navy rescue and salvage equipment.

B.21 HANDLING SYSTEMS

DSSs that are moved about by means of a handling system must have lift points designed to withstand the design load, as defined in Appendix H, without affecting the structural integrity of the hull. The DSS handling system interface design must also consider all the design criteria of Appendix H to evaluate its possible effect on the personnel aboard the DSS.

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APPENDIX C

TESTING PARAMETERS FOR PERMANENTLY OR TEMPORARILY MOUNTED EXTERNAL IMPLODABLE AND EXPLODABLE ITEMS

C.1 INTRODUCTION

This appendix provides guidelines for ensuring that DSSs or DSS personnel are not subjected to underwater explosion or implosion loading, resulting from the failure of an uncompensated DSS component, that would cause the failure of these systems and thereby affect the safety of the DSS personnel.

This appendix is applicable to equipment permanently or temporarily mounted on the DSS, and exposed to ambient submergence pressure during operation of the DSS. This includes:

a. equipment mounted external to a DSS pressure hull or personnel sphere designed to maintain the DSS personnel in a one atmosphere, dry environment;

b. equipment mounted anywhere on a DSS designed to maintain the DSS personnel in a submerged ambient environment; and

c. equipment mounted external to a hyperbaric diving chamber (e.g., PTC) or carried by divers but not previously qualified and listed as ANU by divers.

NOTE: Lockout submersibles represent a hybrid case in which the DSS personnel are maintained in a dry environment for part of the mission, and are exposed to wet ambient conditions for part of the mission. In this case, all explodable or implodable volumes will be evaluated for their effect on the DSS at the maximum design depth. All such volumes classified as critical will be tested in accordance with Sections C.5 and/or C.6 using the maximum design depth of the DSS as the basis for determining the test pressure. Without exception, all other explodable or implodable volumes will be tested in accordance with Sections C.5 and/or C.6 using the maximum depth at which DSS personnel (divers) are expected to enter or exit the DSS as the basis for determining the test pressure.

Pressure hulls/vessels, personnel spheres, buoyancy tanks, air flasks, syntactic foam, and like items are implodable or explodable volumes by definition but are exempt from the requirements of this appendix. These items shall be designed and tested in accordance with Appendix B or some alternative design and testing guidelines which have been approved by the SCA.

The intent of this appendix is to provide a means to determine the structural integrity of items such as light bulbs, cameras, strobes, and other miscellaneous pressure housings. This appendix is not intended to provide an alternative to the design, testing and OQE requirements for pressure hulls and hard structure as outlined elsewhere in this manual.

Proper engineering, whenever possible, will be accomplished in the design and fabrication of an implodable volume to ensure the item will be structurally capable of repetitively passing implosion testing without damage and such that it will perform as intended for the design life. It is the responsibility of the Program Manager to ensure that the applicant has done all that is possible to: a) ensure that the items are structurally adequate to perform as intended for the life of the item, and b) ensure that the item's structural design and integrity can be adequately demonstrated by a one time implosion test. The fact that an item will be subjected to implosion testing does not relieve the designer of the responsibility to properly design and fabricate pressure vessels.

If doubt exists as to a one time implosion test adequately demonstrating the structural integrity of a pressure vessel, especially if the item is fabricated from Category 2 or 3 material, the Program Manager may require that the applicant produce additional evidence to support his position that the item can be treated as an implodable volume and has been adequately tested. The additional evidence may be in the form of design calculations, drawings, material certifications, additional test data, etc.

This appendix is not applicable to items of interest which may be recovered from the sea floor by a DSS. Requests for evaluation of all such items must be directed to the SCA for review, approval, and for determining the necessary recovery parameters. Additionally, this appendix does not cover the requirements for explosive decompression testing of volumes used in pressurized gaseous environments (e.g., recompression chambers or saturation diving chambers). Volumes used in such environments are subject to helium intrusion (or intrusion of some other gas) while at elevated pressures and thus have the potential to explode during the decompression cycle, as well as implode during the compression cycle. For all such volumes subject to explosive decompression, the requirements of Appendix D, in addition to the requirements of this section, apply.

All volumes which contain gas at pressures greater than the ambient external sea pressure have the potential to explode. When such a volume does explode it releases an explosive shock wave. During an explosion a gas bubble expands beyond the point of equilibrium with the surrounding hydrostatic sea pressure. This expanded volume of gas then collapses, causing a pressure pulse. The gas bubble continues to expand and collapse, releasing pressure pulses of decreasing magnitude, until equilibrium with the surrounding hydrostatic pressure is reached. It is the initial explosive shock wave and subsequent pressure pulse that are of concern in the event of an explosion.

All volumes which contain gas at a pressure less than the ambient external sea pressure have the potential to implode. When such a volume does implode it releases a pressure pulse similar to that which is produced when the expanded gas bubble from an underwater explosion collapses. In the event of an implosion it is the initial pressure pulse which is of concern.

C.2 DEFINITIONS

Implodable volume - Any pressure housing containing a noncompensated compressible volume at a pressure below the external ambient sea pressure (at any depth down to maximum operating depth) which has the potential to collapse. The outer shell volume is used when calculating the volume of an implodable. Subtracting the volume of items internal to the implodable is not allowed.

Explodable volume - Any pressure housing containing a volume of gas, at a pressure above the external ambient sea pressure (at any depth) which has the potential to burst. Note that some volumes may be explodable at shallow depths and implodable at deeper depths.

Critical implodable volume- Any implodable volume, which by imploding, affects the safety of the DSS personnel.

Critical explodable volume - Any explodable volume, which by exploding, affects the safety of the DSS personnel.

Noncritical implodable volume - Any implodable volume, which by imploding, does not affect the safety of the DSS personnel.

Noncritical explodable volume - Any explodable volume, which by exploding, does not affect the safety of the DSS personnel.

Minimum required standoff distance - The minimum distance, from any system or item of interest, at which an implodable or explodable volume can be located, such that if an implosion or explosion occurred, the system or item of interest would not be affected (i.e., the distance at which a critical explodable or implodable becomes a noncritical explodable or implodable).

P_{Timp} - Implodable volume test pressure, which is equal to 1.5 times the system's maximum allowable external operating pressure.

P_{Texp} - Explodable volume test pressure, which is equal to 1.5 times the item's maximum allowable internal operating pressure.

C.3 DETERMINATION OF WHETHER OR NOT AN EXPLODABLE OR IMPLODABLE IS CRITICAL OR NONCRITICAL

In order to determine whether or not an implodable or explodable volume is critical (requires testing) or noncritical (does not require testing), the effects of the initial explosive shock wave and/or the initial implosion pulse on all critical systems or components must be analyzed to ascertain whether or not the explosion or implosion would jeopardize the safety of the DSS personnel. If the effects jeopardize the safety of the DSS personnel, then the explodable or implodable is to be classified as critical. Otherwise, the explodable or implodable is classified as noncritical.

NAVSEA recently implemented a method to determine the "criticality" of an implodable or explodable volume. Since the method has been validated for only a limited range of applicability, it is premature to make this technique available for use by the Program Manager. If the Program Manager wishes to employ this method, NAVSEA will assess the suitability of the method for use on the candidate DSS and advise the Program Manager what additional validation (if any) is needed to extend the applicability of the method to the DSS.

In order to conduct the assessment, NAVSEA will require:

a. that the windows and pressure structures be made from materials that allow the methodology to be applied, and

b. that the SCA be provided with detailed structural characteristics of all pressure structures and viewing windows within the DSS.

If the assessment indicates that the method is suitable for the DSS, NAVSEA will conduct the analysis at the request of the Program Manager. However, any testing required to extend the validation of the method to cover the candidate DSS is the responsibility of the Program Manager.

The Program Manager may propose an alternative analytical method for evaluating explodable and implodable volumes. It is incumbent upon the Program Manager to prove the suitability and validity of the method as well as the competence of the individuals who will use it. It is the responsibility of the Program Manager to ensure that all supporting documentation and validation OQE, provided as proof of the acceptability of an alternative analytical method, is complete, thorough, and clear; and, that the appropriate agents of the SCA have been familiarized with the proposed method as needed to facilitate the required NAVSEA review and approval.

If neither of the above options is suitable, or in cases where it is more expedient or cost effective, the Program Manager will classify all explodable and implodable volumes as critical and test each in accordance with Sections C.5 and/or C.6 thereby allowing volumes, so classified and tested, to be placed anywhere in relation to the system/component of interest.

All explodable or implodable volumes on a DSS designed to maintain the operators in an ambient sea pressure environment, and which were not tested to a more severe requirement, will be classified as critical and tested in accordance with Sections C.5 and/or C.6 using the maximum depth at which DSS personnel are expected to operate the DSS as the basis for determining the test pressure.

C.4 TESTING REQUIRED FOR NONCRITICAL IMPLODABLE/EXPLODABLE VOLUMES

There are no testing requirements for implodable or explodable volumes which have been classified as noncritical volumes. However, the potential effect the explodable or implodable has on the system/component is directly related to the standoff distance between the implodable or explodable and the system/component of interest. Thus this standoff distance becomes part of the SOC for that particular volume and system/component combination. For example: An implodable camera housing has a minimum required standoff distance of 4 feet with respect to a personnel sphere. If this camera housing were mounted 5 feet away, anywhere, from the personnel sphere, the camera housing would be classified as a noncritical implodable volume and would require no testing. However, if this same camera housing were located only 3.9 feet from the same personnel sphere, the camera housing would be classified as a critical implodable volume and would require implosion testing.

It is therefore imperative to determine the minimum required standoff for all noncritical implodable or explodable volumes and to retain this information in such a manner that ensures that all noncritical volumes are located no closer than the minimum required standoff to the system/component of interest.

C.5 TESTING NECESSARY FOR CRITICAL IMPLODABLE VOLUMES

All volumes designated as critical implodable volumes, at any depth, shall be tested to 1.5 times the maximum allowable operating pressure (P_{Timp}) for 10 cycles: cycles 1 through 9 shall each be held at (P_{Timp}) for 10 minutes and cycle 10 shall be held at (P_{Timp}) for 1 hour. The test shall be conducted in 35°F seawater, if practical. Leakage or visible signs of damage shall be cause for test failure.

NOTE: All volumes which are certified in this manner will require recertification by implosion testing if repairs or modifications are made which alter the "as-tested" configuration of the volume. The following are examples (not a complete list) of work or conditions that if performed or noticed on a certified (successfully tested) implodable volume will require a retest: welding, grinding, machining, any work that removes material, excessive corrosion, or replacement of a pressure boundary part (except O-rings, gaskets, etc.).

C.6 TESTING NECESSARY FOR CRITICAL EXPLODABLE VOLUMES

All volumes designated as critical explodable volumes, at any depth, shall be tested by pressurizing the volume internally to 1.5 times the maximum allowable internal operating pressure (P_{Texp}) for 10 cycles: cycles 1 through 9 shall each be held at (P_{Texp}) for 10 minutes and cycle 10 shall be held at (P_{Texp}) for 1 hour. Leakage or visible signs of damage shall be cause for test failure.

NOTE: All volumes which are certified in this manner will require recertification by explosion testing if repairs or modifications are made which alter the "as tested" configuration of the volume. The following are examples (not a complete list) of work or conditions that if performed or noticed on a certified (successfully tested) explodable volume will require a retest: welding, grinding, machining, any work that removes material, and excessive corrosion.

C.7 TEST RECORD OQE REQUIRED FOR CRITICAL IMPLODABLE AND EXPLODABLE VOLUMES

Unless otherwise approved by NAVSEA, a submergence Pressure Test Record shall be kept for all components tested in accordance with Sections C.5 and C.6. Records, as a minimum, shall include the following information:

a. Name(s) and serial number(s) of component(s) tested.

b. Date of test.

c. Serial number(s) of gage(s) used for the test.

d. Last calibration date of the pressure gage(s) used in the test.

e. Next calibration due date of the pressure gage(s) used in the test.

f. Test medium temperature required and actual test medium temperature used.

g. Pressure range and accuracy of gage(s) used.

h. Test pressure for each pressure cycle.

i. Required and actual duration of each pressure cycle.

j. Results of inspection for leakage or visible signs of damage.

k. Printed name(s) and signature(s), or Identification Number(s) and signature(s) of test conductor(s) and/or inspector(s) and the date of each signature.

APPENDIX D

TESTING PARAMETERS FOR EXPLODABLE ITEMS DUE TO DECOMPRESSION

D.1 INTRODUCTION

During the design process, particular attention will be given to the shrapnel effects produced by the explosion of items such as interior lights and instrument bulbs inside the DSS and to the prevention of these occurrences.

Many devices are subject to inadvertent explosion during decompression because they have been infiltrated by helium or other gases during a compression cycle. These devices, in themselves, may become hazards within the DSS and as such this phenomena should be considered during the design process.

At the present time, there is no known analytical method for determining the material adequacy of items within a DSS which may explode and cause a casualty. Therefore, to achieve a maximum reasonable level of assurance for these items, this appendix contains the requirements for determining the material adequacy of all such items.

D.2 DESCRIPTION AND ORIENTATION

Data of the manned DSS spaces shall be reviewed to determine and describe the size, quantity, and locations of all potentially explodable items. All such items shall be explosive tested as described below. If 100 percent batch testing is impractical or otherwise considered unnecessary, the Program Manager may request a waiver of the 100 percent testing requirement in accordance with Section 2.4 of this manual. The Program Manager shall provide detailed justification for the waiver and shall provide a procedure for selecting the batch sample size. The approved sample will be tested in accordance with the requirements of this appendix.

D.3 TEST PROCEDURE

Each item selected should be tested as follows:

a. Subject the item to a pressurized soak test, using a test medium (e.g., water, air, helium) representative of the actual environment in which the explodable item will operate. For convenience, it may be permissible to substitute a test medium (e.g., air for water or helium for air) which is more likely to infiltrate the test article. The time of the soak shall be at least 2.0 times the maximum expected exposure period. The pressure shall be the maximum operating pressure of the DSS.

b. Following the soak test, depressurize the test chamber at a rate not less than 1.5 times the maximum depressurization rate of the manned space.

c. Items that do not show evidence of physical deterioration or damage shall be acceptable for service.

d. Items that do show evidence of physical deterioration or damage shall be rejected.

e. Depending on the type of failure, rejected items may be allowed to be repaired and then undergo a retest. If these items successfully pass the retest they will be acceptable for service. SCA approval must be obtained for items the Program Manager wishes to retest. The Program Manager shall submit all information requested by the SCA in order to make this determination.

D.4 POROUS OR VENTED COMPONENTS

Porous or vented components of an explodable item, which by their construction or design are known or intended to continuously equalize their internal pressure with ambient external pressure, shall be shown to have the ability to intake and exhaust a test medium, representative of the actual operating environment, within the maximum pressurization/depressurization rates of the system in order to provide assurance that the porous or vented components will not explode during pressurization or depressurization. Testing done in accordance with Section D.3 above, including authorized substitutions of test medium, will provide this assurance.

APPENDIX E

DSS BREATHING GAS AND ATMOSPHERIC REQUIREMENTS

E.1 INTRODUCTION

The composition of a breathing gas and the quantity required are dictated by the physiological characteristics of the human body. General breathing gas requirements for DSSs are described in this appendix. For more specific information on breathing gas requirements refer to the Nuclear Powered Submarine Atmosphere Control Manual, NAVSEA S9510-AB-ATM-010, and the U.S. Navy Diving Manual, NAVSEA 0994-LP-001-9110 (Volume 1) and NAVSEA 0994-LP-001-9020 (Volume 2).

The effect of gases on the body is determined primarily by the partial pressure of the gas, not its relative concentration. It is, therefore, better to speak in terms of partial pressure of a gas rather than a percent of the total volume. Partial pressure is easily converted to percent of the total volume by dividing the gas partial pressure by the absolute pressure of the environment, usually expressed in atmospheres.

Present evidence indicates that the physiologic mechanisms of respiration which detect and control the partial pressure of oxygen and carbon dioxide in the blood stream, as well as respiratory volume, continue to function adequately in a closed environment, even when the pressure is elevated.

E.2 BREATHING GAS CONSUMPTION

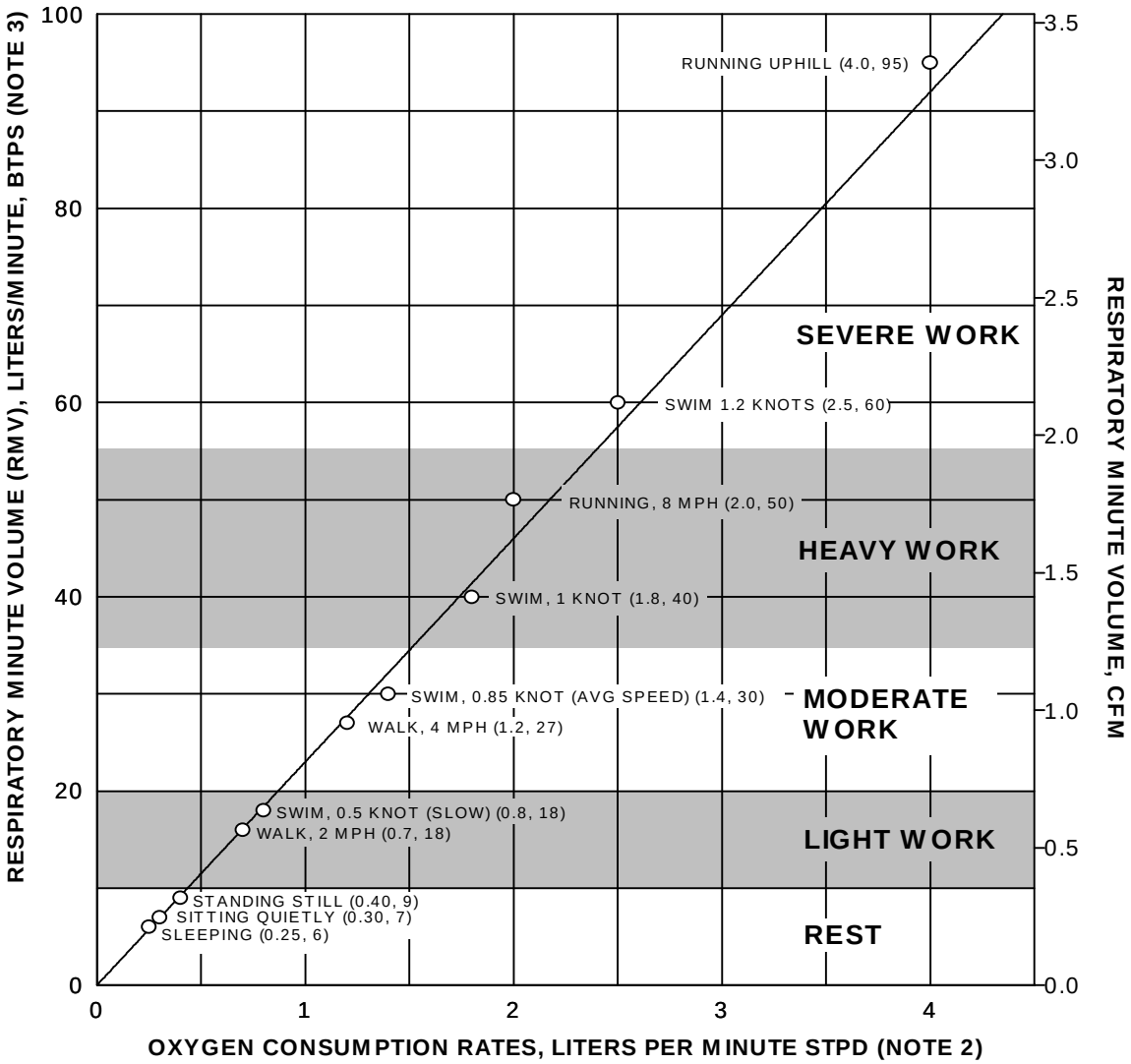
Breathing gas is a mixture containing oxygen, part of which is consumed in respiration, and an inert diluent gas (or gases) such as nitrogen or helium, which is not consumed or altered. The oxygen consumed in the body reacts with the fats, carbohydrates, and proteins to produce energy, carbon dioxide, and water. During the breathing cycle, oxygen removed from the breathing gas is replaced by a nearly equal volume of carbon dioxide.

In the closed environment of a DSS, the occupants will consume oxygen as part of their normal metabolic process. Figure E-1, derived from NAVSEA 0994-LP-001-9110, shows the range of oxygen consumption rates for various activities. From a practical standpoint the minimum oxygen consumption rate for an individual is 0.25 liters/minute, and the maximum is 4.0 liters/minute. If no oxygen is added to the closed environment the oxygen fractional concentration will decrease linearly (assuming a constant consumption rate) with time according to the formula (Section E.7.2).

Table E-1 gives the symptoms which would occur as the oxygen partial pressure is lowered.

E.3 SURFACE BREATHING AIR REQUIREMENTS

The volume of breathing gas (air) needed for a DSS operating at one atmosphere may be determined using Figure E-1 and taking into consideration the total of all aspects of DSS personnel activity.



Notes:

1. All figures are average values. There is considerable difference between individuals.

2. STDP means "standard temperature and pressure, dry gas." As given here, it is medical STDP (i.e., 32°F, 1 ata, dry gas). For oxygen cylinder endurance or helmet ventilation calculations, the numbers should be multiplied by 1.08 to yield engineering STPD.

3. BTPS means "body temperature (98.6°F), ambient barometric pressure, saturated with water vapor at body temperature." For open-circuit SCUBA endurance calculations, this value should be multiplied by 0.95 to give corresponding values for dry gas at 70°F. The 0.95 factor ignores the difference in the water vapor content between dry and saturated gas, but this is very small at most diving depths.

Figure E-1. Relation of Respiratory Minute Volume and Oxygen Consumption Rate to Type and Level of Exertion

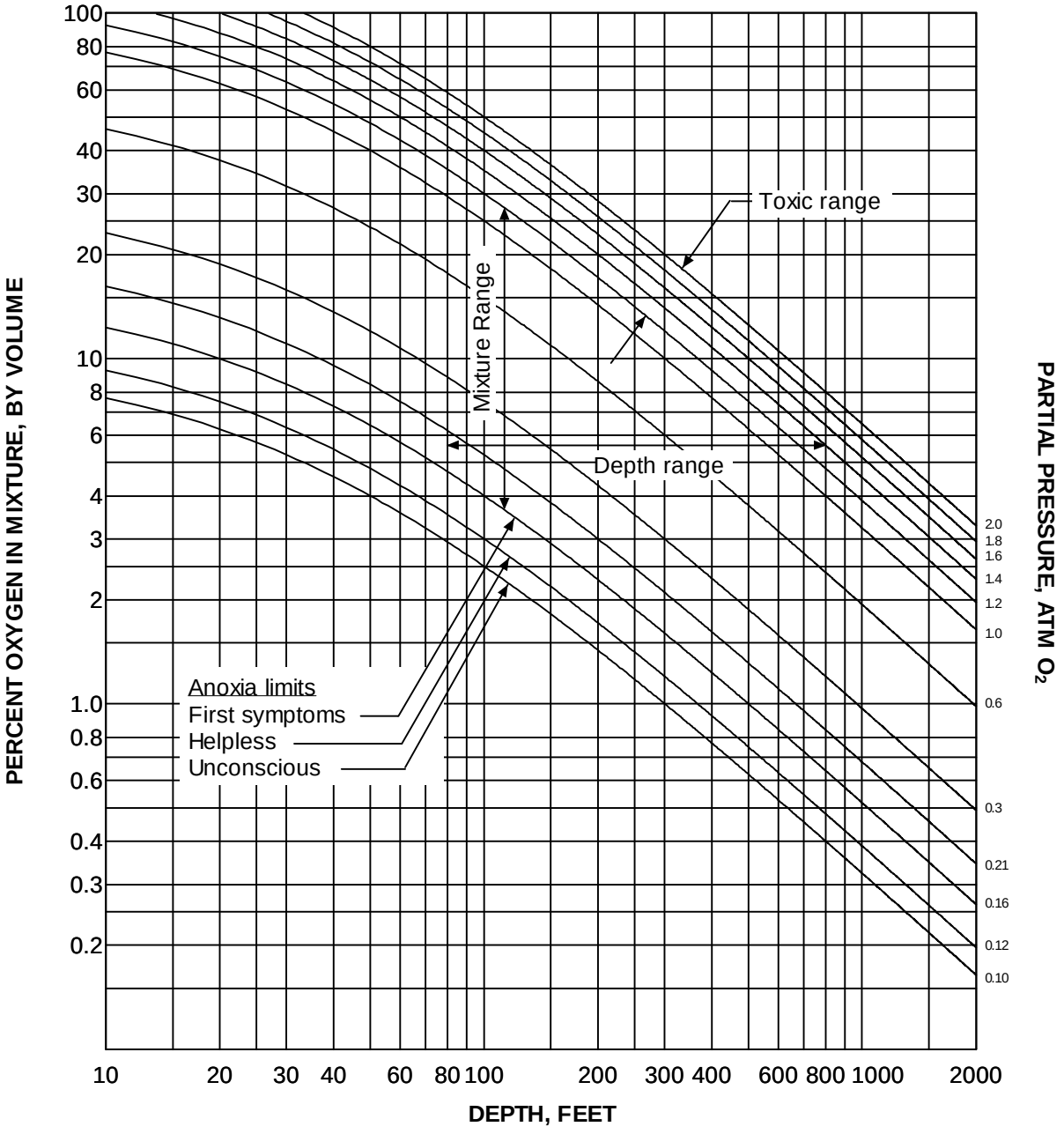
Table E-1. Effects of Various O_2 Partial Pressures

Oxygen Partial Pressure (Atmosphere)	Effect
Greater than 1.6	Central nervous system toxicity - convulsion, onset of symptoms varies somewhat from person to person
Greater than 0.5	Pulmonary oxygen toxicity - painful inspiration - possible permanent lung damage depending on exposure time
0.2 - 0.5	No toxicity
0.18 - 0.21	Normal sea-level conditions
0.16 - 0.12	Increased breathing rate, lack of coordination
0.14 - 0.10	Easily tired, easily upset emotionally, loss of sensitivity to pain or injury, abnormal fatigue from exertion
0.10 - 0.06	Lethargic; apathetic; confused thinking; physical collapse; possible unconsciousness, nausea and vomiting
0.06 - or less	Convulsive movement, gasping, cessation of breathing

E.3.1 Surface Oxygen Requirements

The normal surface oxygen control range should be 18 to 21 percent (0.18 to 0.21 atm partial pressure). Excessive oxygen in a person's blood will cause a toxic reaction. On the other hand, insufficient oxygen in a person's blood will result in unconsciousness. The amount of oxygen that goes into the blood is directly related to the partial pressure of oxygen in the subject's breathing gas mixture. Neglecting other effective factors, such as time of exposure, the inert gas in the breathing gas mixture, and exertion, it can be initially assumed that an acceptable breathing medium (gas mixture) must expose its user to not less than 0.16 atmosphere, partial pressure, and not more than 1.2 atmospheres, partial pressure, of oxygen. Table E-1 shows the range of effects of various partial pressures of oxygen on human subjects.

Figure E-2 relates oxygen partial pressure isobars, and hence physiologic effect of oxygen, to percent oxygen in the gas mixture and depth. A large area within which mixtures are physiologically acceptable for a few hours is bounded on the lower side by curves defining different levels of anoxia (oxygen deficiency) and on the upper side by curves of oxygen toxicity. It will be noted in Figure E-2 that the first symptoms of anoxia occur when oxygen partial pressure falls to 0.16 atm, and that DSS personnel become helpless when oxygen partial pressure drops to 0.12 atm.



$$\text{Percent } O_2 = \frac{\text{Partial Pressure } O_2\text{, (atm) x 100}}{\text{Seawater Pressure, (atm)}}$$

Figure E-2. Oxygen Partial Pressure Isobars as a Function of Percentage of Oxygen in Breathing Mixture and Depth

In the region of high oxygen concentration, toxic effects on the central nervous system, leading to convulsions and unconsciousness, limit the duration of exposure at oxygen partial pressures above 1.6 atm. The actual allowable duration of exposure is reduced by CO_2 in the inspired gas and by exertion, and varies somewhat with the mission and with the type of DSS.

Alarm set points should be 17 and 23 percent (0.17 to 0.23 atm partial pressure), including for temperatures as low as 34°F. Under no circumstances should the oxygen concentration fall below 16 percent (0.16 atm partial pressure). If the alarm limits are exceeded, immediate corrective action should be taken. Because of fire prevention considerations, if the concentration of oxygen ever exceeds 25 percent or if the corrective action fails to return the oxygen concentration to within the limits, the DSS should begin abort procedures.

E.3.2 Carbon Dioxide Production and Toxic Effects

If carbon dioxide is included in an inhaled gas, the partial pressure of carbon dioxide in the blood increases, and the respiratory center in the brain increases ventilation (tidal volume and/or breathing rate) in an attempt to restore blood carbon dioxide to normal levels. Excessive amounts of carbon dioxide in the breathing gas results in toxic effects, the severity of which depends upon exposure time and the partial pressure of carbon dioxide.

Figure E-3 shows the relation of physiological effects of carbon dioxide for different concentrations and exposure periods. In Zone I, no perceptible physiological effects have been observed. In Zone II, small threshold hearing losses have been found and there is a perceptible increase in depth of respiration. In Zone III, the zone of distracting discomfort, the symptoms are mental depression, headache, dizziness, nausea, air hunger, and decrease in visual discrimination. Zone IV represents marked physical distress leading to dizziness and stupor, with the inability to take steps for self-preservation. The final state is unconsciousness.

The bar graph at the right of Figure E-3, for exposure of 40 days, shows that concentrations of carbon dioxide in air of less than 0.005 atm partial pressure (Zone A) cause no biochemical or other effects. Concentrations between 0.005 and 0.03 atm partial pressure (Zone B) cause adaptive biochemical changes, which may be considered a mild physiological strain, and concentrations above 0.03 atm partial pressure (Zone C) cause pathological changes in basic physiological functions.

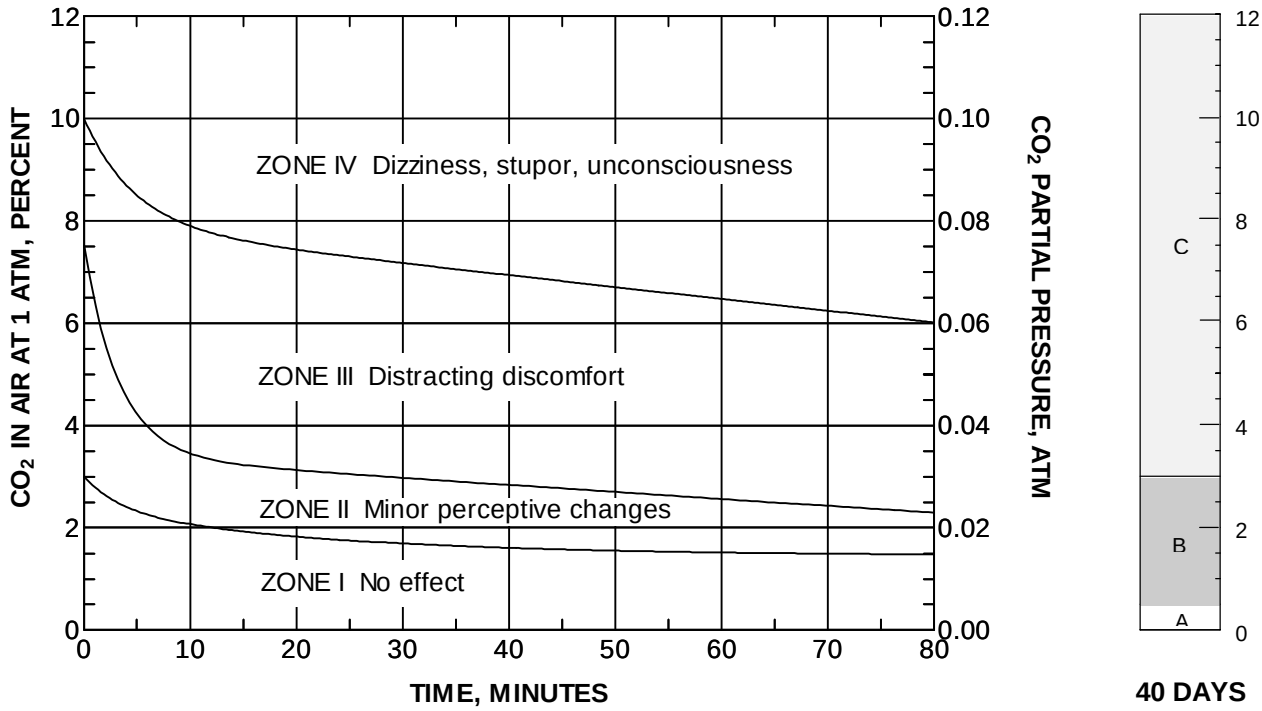


Figure E-3. Relation of Physiological Effects of Carbon Dioxide Concentration and Exposure Period

Respiration accounts for most of the carbon dioxide generated in a DSS. During the breathing cycle, oxygen is removed from the breathing gas and replaced in a certain proportion by CO_2. The proportion of volume of CO_2 released to the volume of O_2 consumed varies from 0.7 to 1.1, depending upon the chemical composition of the energy source, level of exertion, and other factors. The average resting oxygen consumption is approximately 0.44 slpm (1.0 scfh) per man, and the corresponding average CO_2 generation rate has been observed to lie between 0.352 and 0.374 slpm (0.80 and 0.85 scfh) depending upon dietary and other considerations. This is equivalent to 46 gm (0.1 lb)/man-hour. The ratio of the volume of CO_2 produced to volume of O_2 consumed is termed the respiratory quotient (RQ). Therefore:

$$RQ = \frac{\text{Volume of } CO_2 \text{ produced}}{\text{Volume of } O_2 \text{ consumed}} = \frac{0.85}{1} = 0.85$$

E.3.3 Carbon Dioxide Removal

In the closed environment of a DSS, CO_2 is usually removed by an absorbent material (e.g., lithium hydroxide, soda sorb or baralyme). Environmental gas (i.e., air), is passed through a canister containing the CO_2 absorbent material and returned to the DSS atmosphere. Regardless of which CO_2 absorbent is used, the CO_2 level in the atmosphere will never reach zero.

E.3.4 Carbon Dioxide Levels

Figure E-4 shows CO_2 tolerance zones as a function of percentage CO_2 and depth at partial pressures taken from Figure E-3 for 1-hour exposure period. As with oxygen, the physiological effects of carbon dioxide depend upon its partial pressure in the blood and therefore in the breathing gas. The percentage of carbon dioxide in the breathing gas that can be tolerated at diving depths decreases with depth, and the respiratory volume required to ventilate the lungs at depth remains approximately equal to that at sea level.

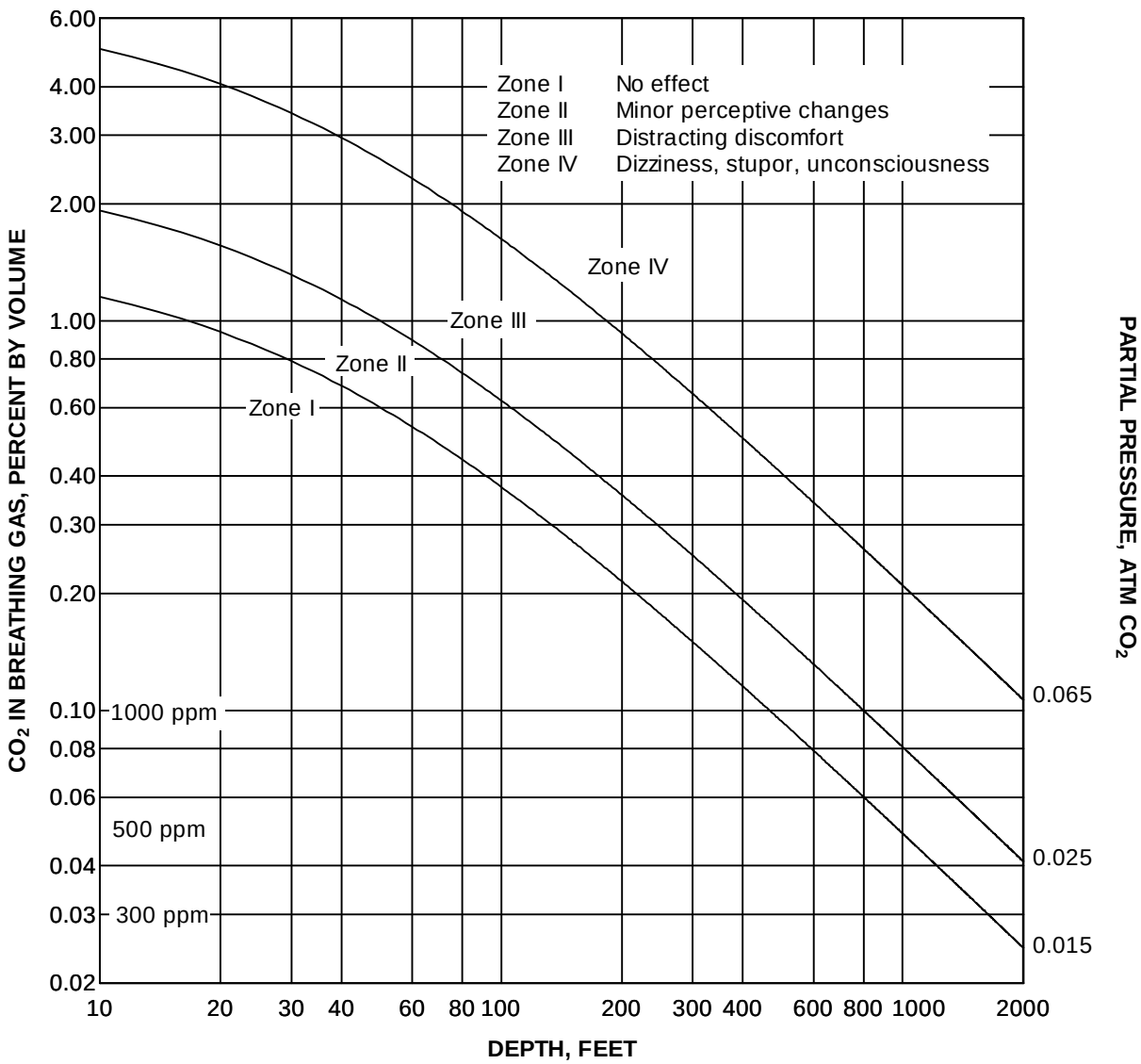


Figure E-4. Relation of Co_2 Tolerance Zones to Depth and Percentage of Co_2 in Breathing Gas

E.4 ATMOSPHERIC CONTAMINANTS

A DSS's atmosphere ideally would contain only oxygen, carbon dioxide and a diluent gas (e.g., nitrogen or helium). Unfortunately this is not usually the case. Under actual conditions a myriad of other constituents are present. These contaminants are the result of such things as off-gassing from plastics, insulation, glues, clothing, and even the occupants. A detailed discussion of atmospheric contaminants and the associated requirements is contained in Appendix F.

E.5 CARBON MONOXIDE LEVELS

Although experimental data relating CO concentrations to toxic effects in helium/oxygen mixtures are not currently available, effects can be predicted with reasonable assurance based upon CO/O_2 ratio equivalent of 0.5 ppm CO for each percent of oxygen in the breathing gas. On this basis the limit for CO in air containing 21 percent O_2 would be 0.5 ppm of CO/percent times 21 percent O_2 or 10.5 ppm. This relates to a P_{CO} of 10.5×10^{-6}. It is recommended that a maximum of 10.5×10^{-6} P_{CO} be permitted for prolonged exposure at depths greater than 800 feet, pending further studies of Threshold Limit Values (TLVs) of trace contaminants in hyperbaric environments.

Concentrations of P_{CO} higher than those noted above can be tolerated with levels of discomfort in emergencies. For example breathing air which contains as much as 150 to 250 ppm of CO, at one atmosphere for many hours will result in a severe headache. On the other hand, breathing air contained 1600 ppm of CO at one atmosphere for one hour will cause confusion and ultimate collapse.

E.6 DECOMPRESSION CONSIDERATIONS

Decompression considerations also influence the selection of breathing gas composition. The length of the decompression period is a function of the partial pressure of diluent gas (helium or nitrogen) in the breathing mixture. The decompression period can be shortened by using oxygen concentrations close to the toxic limit during a scheduled diving period and during the decompression period. Oxygen bubbles are not normally a limiting factor in decompression as oxygen is readily metabolized. This approach is most effective for dives at shallow to moderate depths when the proportion of oxygen can be large enough to significantly reduce the partial pressure of diluent gas. Under certain conditions, use of a high oxygen mixture may eliminate the decompression period entirely.

The oxygen percentages shown in Figure E-2 would be appropriate with any diluent gas or mixture of diluent gases that might be applicable to diving. Oxygen-nitrogen mixtures, including air, can be used freely if nitrogen partial pressure is limited to 3 atm, the pressure at which the first gross symptoms of narcosis appear, and

nitrogen partial pressures to 5.5 atm can be used with care by experienced DSS personnel for short periods. (This is equivalent to diving at 200 feet with air.) For greater depths, helium is the diluent gas now generally used because it does not produce a narcotic effect at any practical diving depth and because its low density reduces breathing effort. The principal disadvantages of helium are its limited availability and resulting high cost, the effect that it has on the voice which makes communication difficult, and the high leakage rates experienced in joints and seals.

E.7 BREATHING GAS ALGORITHMS

The following algorithms define the steady state and transient characteristics of gas and contaminants in a closed space environment. These algorithms shall not be applied to diver supported systems. For this application, suitable procedures and algorithms are contained in NAVSHIPS 0994-LP-003-7010, U.S. Navy Diving-Gas Manual.

E.7.1 Conversion Factors

a. Gas Volume Percent to Partial Pressure:

(Gas%/100) x (Ambient Pressure-psia/14.7 psig), or

(Gas%/100) x (Ambient Pressure-atmosphere absolute)

b. Milligrams Per Cubic Meter to Parts Per Million at 1 atm:

[(24.45) (mg/m^3)]/(gas molecular weight)

c. Flow Rate Corrected to Standard Temperature and Pressure

$$Q_{stp} = \frac{(Q_a)\,[(P_a)\,(T_{stp})]}{[(P_{stp})\,(T_a)]}$$

Where:
Q_{stp} = Flow Rate at STP (standard volume/time)
Q_a = Actual Flow Rate (volume/time)
P_a = Actual Pressure (psia or ATM)
T_{stp} = Temperature at STP (528 R or 341 K)
P_{stp} = Pressure at STP (14.7 psia or 1.0 ATM)
T_a = Actual Temperature (F+460 or C+273)

E.7.2 Steady Oxygen Production and Removal Process

$$t = \frac{(O_{2f} - O_{2i})(V)}{I - R}$$

Where:
- t = Time
- O_{2f} = Final Oxygen Concentration (vol/vol)
- O_{2i} = Initial Oxygen Concentration (vol/vol)
- V = Compartment Floodable Volume (vol)
- I = Oxygen Introduction Rate (vol/time)
- R = Oxygen Removal/Usage Rate (vol/time)

E.7.3 Carbon Dioxide Buildup With No Removal Process

$$CO_{2f} = CO_{2i} + \frac{(RQ)\,(RO_2)\,(t)\,(N)}{V}$$

Where:
- CO_{2f} = Final CO_2 (% or partial pressure)
- CO_{2i} = Initial CO_2 (% or partial pressure)
- RQ = Respiratory Quotient (dimensionless)
- RO_2 = Oxygen Breathing Usage Rate (vol/time)
- t = Time
- N = Number of Personnel Breathing
- V = Compartment Floodable Volume (vol)

E.7.4 Steady Contaminant Introduction And Removal Process

$$t = \frac{V\,[\mathrm{Ln}\,(C_i - C_{eq})]}{Q_f\,(C_f - C_{eq})}$$

Where:
- t = Time
- V = Compartment Floodable Volume
- Ln = Natural Log
- Q = Flow Rate of Process Removing Contaminant, i.e., CO_2 scrubber flow rate (vol/time)
- f = Process Efficiency (decimal)
- C_i = Initial Contamination Concentration (vol/vol)
- C_f = Final Contamination Concentration (vol/vol)
- C_{eq} = Equilibrium Contamination Concentration after infinite time (vol/vol) = I/R_f, where:
- I = Contaminant Introduction Rate (vol/time)

E.7.5 No Contaminant Introduction But Constant Removal Process

$$C_f = (C_i)\, e^{-(Qft/V)}$$

Where:
- C_i = Initial Contaminant Concentration (vol/vol)
- C_f = Final Contaminant Concentration (vol/vol)
- Q = Flow Rate of Process Removing Contaminant, i.e., CO_2 Scrubber flow rate (vol/time)
- f = Process Efficiency (decimal)
- t = Time
- V = Compartment Floodable Volume

E.7.6 Expected Contamination From a Volatile Solvent

$$C = \frac{(L)\,(p)\,(24{,}450{,}000)\,(F)}{(V)\,(M)}$$

Where:
- C = Expected Contaminant Concentration (ppm)
- L = Volume of Volatile Solvent (ml)
- p = Volatile Solvent Density (gm/cm^3)
- F = Volume Fraction on Solvent Existing in a Vapor (dimensionless)
- V = Compartment Floodable Volume
- M = Solvent Molecular Weight

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APPENDIX F

GENERAL GUIDELINES FOR CONTROL OF ATMOSPHERIC CONTAMINANTS IN MANNED DSS

F.1 INTRODUCTION

The DSS Program Manager shall establish controls to minimize the release, introduction, and generation of contaminants into the atmosphere of any manned space. DSS atmospheres shall be monitored to verify a safe atmosphere exists and to verify the effectiveness of the control program. DSS, in general, represent very small, confined manned spaces that can allow contaminants to rapidly increase to unacceptable concentrations if proper administrative and engineering control and monitoring are not performed.

F.2 DSS FACTORS EFFECTING ATMOSPHERE CONTROL

There are numerous factors inherent in the design and operation of the DSS that effects what level of control and monitoring will be required.

F.2.1 Mission Duration

The longer the mission, the more time contaminants have to build-up, and the longer personnel will be exposed to the contaminants. Most published guidelines for occupational exposures from organizations such as the Occupational Safety and Health Administration (OSHA), American Conference of Governmental Industrial Hygienists (ACGIH) and National Institute for Occupational Safety and Health (NIOSH) generally assume only 8 to 10 hours per day, 40 hours per week exposure. These occupational exposure guidelines assume industrial environments where contaminants are expected to be continuously generated. Historically, there has not been any significant industrial or scientific activity performed in an operational DSS. This reduces the probability that contaminants will continue to accumulate throughout a DSS mission. However, unlike industrial environments where the number of contaminants is generally limited, DSS platforms, like submarines and spacecraft, often expose occupants to a wide range of contaminants. While there are various methods of evaluating the health risk of extended exposures and exposure to multiple contaminants (see Section F.6), DSS, for ease of implementation, have historically selected exposure limits much lower than those established by OSHA or ACGIH. This has mitigated the health risk of exposure durations in excess of 8 hours, and exposure to multiple contaminants. Furthermore, as an additional safety factor, the sample period used for measuring the actual build-up of contaminants in the DSS has been for durations much longer than 8 hours; generally 24 hours. The assumption has been that after the sample period, the contaminant concentration in the DSS will not accumulate beyond specified limits (see Section F.5). This is much more conservative

than the basis used in occupational exposure guidelines that can allow 8 hours continuous exposure at the limit. These issues notwithstanding, the effect of mission duration and multiple contaminant exposure on allowable exposure limit requires careful review by the appropriate medical department personnel.

F.2.2 Atmospheric Pressure

As the pressure increases, contaminant release from materials may increase resulting in increased exposure to personnel. Additionally, at higher atmospheric pressures, personnel tolerance of contaminants may decrease. Any material that contains voids, such as foam, will deform under pressure possibly releasing trapped gases. A hazard to personnel could exist if these gases are potentially toxic.

When working with pressurized environments, contaminant concentrations are generally referenced to standard atmospheric conditions and referred to as surface equivalent value (SEV). When pressure in a space increases because of the addition of clean air with no change in the floodable volume, the concentration of any contaminants in the space will decrease in terms of parts per million (ppm), but remain unchanged in terms of milligrams per cubic meter (mg/m^3) or partial pressure (atmospheres absolute - ata). As an example, if a one atmosphere space containing 1000 ppm of a contaminant is pressurized to two atmospheres by the addition of clean air, the contaminant concentration will decrease to 500 ppm, but its concentration in terms of 'mg/m^3' or partial pressure (ata) will remain unchanged. The SEV will be 1000 ppm.

When pressure in a space increases because of a reduction in floodable volume, the concentration of contaminants will remain the same in terms of 'ppm', but will increase in terms of 'mg/m^3' and partial pressure (ata). As an example, if a one atmosphere space containing 1000 ppm of a contaminant is pressurized to two atmospheres by reducing the floodable volume, the contaminant concentration will remain at 1000 ppm, but its concentration in terms of 'mg/m^3' or partial pressure (ata) will double. The SEV will be 2000 ppm.

When the source of the contaminants is the supply gas and the pressure in a space increases because of addition of supply gas with no change in floodable volume, the concentration of any contaminants in the space will remain unchanged in terms of 'ppm', but will increase in terms of 'mg/m^3' or partial pressure (ata). As an example, if a one atmosphere space containing 1000 ppm is pressurized to two atmospheres by the addition of supply gas containing 1000 ppm of the same contaminant, the contaminant concentration in the space will be 1000 ppm, but its concentration in terms of 'mg/m^3' or partial pressure (ata) will double. The SEV will be 2000 ppm. Verifying the quality of breathing gas before use, and properly cleaning and maintaining cleanliness of breathing gas systems are actions taken to ensure breathing gas purity (See Section F.3.3).

F.2.3 Material Density

The greater the quantity (weight) and volume (geometry) of non-metallic material installed into a given surface equivalent space, the greater the density of non-metallic material. Non-metallic material density is generally expressed as grams per liter. Large quantities of non-metallic material can release large volumes of contaminants, and subsequently cause high concentrations of contaminants in the DSS manned space. Because density of non-metallic material will vary, only appropriate review by engineering and medical department personnel can determine extension of material acceptability from one project to another.

F.2.4 Atmospheric Temperature

The higher the temperature, the greater the rate of contaminant generation. Additionally, the higher the temperature, the greater the probability that material may release (off-gas) contaminants that did not off-gas at lower temperatures. Materials used in DSS are evaluated for off-gas constituents at the maximum operational temperature. Where transport or storage can subject the DSS to higher temperatures, evaluating materials at the higher temperature should be considered.

F.2.5 Atmospheric Control Equipment

The type of equipment used to control the atmosphere can impact the type of contaminants generated. The most common type of atmospheric control equipment used on DSS is carbon dioxide scrubbers. The alkaline based chemicals used in this equipment can decompose certain types of halogenated solvents into very toxic and reactive compounds that are not easily monitored. In this case, the precursor (initial) chemical is controlled at a level far below its common exposure guideline to minimize the potential for exposure to decomposition products.

F.2.6 Cleanliness

The natural build-up of soils from food, occupants, and equipment during operation and maintenance can effect the atmosphere of a DSS. Routine housekeeping is necessary to prevent these natural occurring soils from increasing to a level that could contaminate the atmosphere. Of equal importance is the use of appropriate cleaning agents to prevent inadvertently introducing additional contaminants. Additionally, when operating in contaminated waters, diver decontamination procedures may be necessary to prevent introducing unacceptable levels of contaminants into a DSS.

F.3 CONTROLLING AND MONITORING CONTAMINANTS

F.3.1 Background

Contaminants can be released or introduced into a DSS from three basic sources:

a. Personnel. Personnel inhabiting the space will release contaminants into the atmosphere. The most common contaminant is carbon dioxide naturally produced during the metabolism of oxygen. Other contaminants released by personnel may include carbon monoxide; methane; ethanol; hydrogen; ammonia and other amino based hydrocarbon compounds.

b. Breathing Gas. Gas supplied to the DSS to maintain a breathable atmosphere can introduce contaminants. The most common gases used on DSS are oxygen used to make-up for metabolic usage, and air and helium used for pressurization. Any unacceptable level of contamination in these gases or the systems supplying these gases will ultimately effect the quality of the DSS atmosphere.

c. Material. Non-metallic materials, including those in processes used to manufacture materials used in the DSS, can release contaminants into the atmosphere. Examples include any non-metallic material that cures such as paints, adhesives, resins and solvents. These types of materials will off-gas contaminants until cured. Additionally, non-metallic material that can trap contaminants such as foams, that may use refrigerants to blow the foam, can also release contaminants into an atmosphere. Furthermore, materials which remain elastic, such as rubber hoses, can release relatively low concentrations of contaminants for very long periods of time.

F.3.2 Controlling Personnel Contaminants

Given a supply of clean breathing gas, the generally regarded single greatest threat to confined space occupancy is the build-up of carbon dioxide. All DSS employ some form of carbon-dioxide removal. The most common method is to absorb carbon dioxide using alkaline salts such as Calcium Hydroxide (commercially known as Sofnolime and Sodasorb) and Lithium Hydroxide. The design of carbon dioxide scrubbers is beyond the scope this manual. However, the design and its integration into the DSS at both one atmosphere and maximum operating pressure (depth) shall be verified prior to final certification. During initial one atmosphere manned testing, the ability of the carbon dioxide removal system to function as designed shall be demonstrated and evaluated. The major items to be demonstrated are the capacity and efficiency of the absorbent with the space fully manned, and preferably at the lowest operational temperature. This data will support determining the final DSS carbon dioxide absorbent load-out. Subsequent manned testing at maximum depth shall be as specified by the approved integrated test. However, performance of carbon dioxide removal equipment for any DSS operating at greater than one atmosphere shall be evaluated by unmanned testing at the maximum operating depth prior to manned testing at that depth.

The build-up and control of other personnel contaminants such as carbon monoxide, methane, ethanol, hydrogen, ammonia, hydrogen sulfide and other amino based hydrocarbon compounds needs to be addressed during the design of the DSS

Atmospheric Control System. Factors such as number of personnel, mission duration, occupied space volume, human waste stowage, and breathing gas exchange (if possible) will determine if controls are necessary. The simplest form of control includes passive methods such as the following:

a. Activated Carbon which can adsorb high molecular weight hydrocarbons, alcohols, ketones, aldehydes, and organic acids. When impregnated with phosphoric acid, it can also remove ammonia and other organic bases.

b. Purafil (activated alumina impregnated with potassium permanganate) adsorbs a number of acid and alkaline gases, and will also oxidize many unsaturated hydrocarbon compounds.

c. Unheated Hopcalite (a mixture of oxides of manganese, copper, cobalt and silver) will remove carbon monoxide via catalytic oxidation, and to a lesser extent, hydrogen. Unheated Hopcalite is often used on diesel driven and/or oil lubricated compressors providing breathing air.

The one personnel contaminant that can not be removed passively is methane. If mission duration will cause methane to be a problem, more aggressive engineering and chemical control of human waste should be used. This includes active methods such as the high temperature burners used in fleet submarines.

F.3.3 Controlling and Monitoring Breathing Gas Purity

The purity of breathing gases shall be specified in accordance with applicable commercial, federal, or military specifications, modified as necessary to correct for DSS SEV and contaminant limits, and approved by the Program Manager and SCA. The following breathing gas standards have been used (sometimes modified) on DSS platforms.

a. NAVSEA 0994-LP-001-9110, U.S. Navy Diving Manual (Volume I)

b. BB-A-1034 - Federal Specification; Air, Compressed for Breathing Purposes.

c. MIL-O-27210 - Military Specification; Oxygen, Aviators Breathing, Liquid, Gas.

d. BB-N-411 - Federal Specification; Nitrogen, Technical.

e. MIL-P-27407 - Military Specification, Propellant Pressurization Agent Helium

Compressed air provided from an on-site certified charging complex (compressor and filters) shall be tested for compliance with the approved purity standard every 6 months, or as otherwise approved by NAVSEA.

Each lot of compressed gas supplied by a vendor shall be tested for compliance with the approved purity standard prior to manned use. Testing shall be accomplished by either the vendor (by providing a certificate of analysis) or the user. A vendor certificate of analysis is acceptable only if the sample was taken from a delivered storage container. This ensures that the cleaning process use by vendor to clean the storage tank does not introduce unacceptable contaminants into the breathing gas.

Gases batch blended by performing partial pressure mixes, or gases continuously blended using appropriate equipment shall be tested for compliance in accordance with a sampling plan approved by Program Manager and SCA.

F.3.4 Controlling and Monitoring Gaseous Contaminants in Breathing Gas Systems

Breathing gas piping systems can become contaminated from the use of improper lubricants, improper materials, improper cleaning agents or cleaning processes, and improper methods for maintaining cleanliness.

For initial certification, breathing gas piping systems shall be analyzed to verify gaseous contaminant concentrations are within acceptable limits (see Section F.5) prior to manned use. Prior to sampling, the applicable system shall be pressurized with system gas or nitrogen to not greater than 500 psig, (do not exceed normal system operating pressure) for not less than 24 hours. Multiple gas samples shall be taken to analyze for gaseous contaminants in each gas bank, and each high and low pressure section separated by a pressure reducing device. Sampling for laboratory analysis shall be performed using clean, dry evacuated stainless steel containers (or other appropriate container) in accordance with locally approved procedures. Refer to PSNSY IPI 0558-839 for examples of acceptable procedures used to draw pressurized gas samples.

Breathing equipment/systems operating within and at approximately the same pressure as a manned compartment, or breathing equipment/systems that recirculate manned compartment atmosphere are not considered part of the breathing gas piping system. These items, such as emergency breathing loops, are considered part of the compartment (which is generally not SEV corrected) and shall be tested as specified in Section F.3.5.

After initial certification, sampling of the breathing gas piping system following maintenance and repair is not required provided the following is accomplished:

a. Replacement piping and components are cleaned as specified in Appendix G.

b. Any component (such as a gauge for diver life support systems) cleaned with a NAVSEA approved halogenated solvent is dried as specified by MIL-STD-1330 or MIL-STD-1622 prior to installation.

c. Replacement non-metallic material is as specified in Section F.4.4.

d. Cleanliness is maintained in accordance with MIL-STD-1330 or MIL-STD-1622.

F.3.5 Monitoring Gaseous Contaminants in the DSS

The atmosphere of each manned space shall be tested to verify contaminant concentrations are within acceptable limits (see Section F.5) for human occupancy. Sampling for laboratory analysis shall be performed using clean, dry evacuated stainless steel containers (or other appropriate container) in accordance with locally approved procedures. The contractor or user is cautioned that some target compounds specified in Section F.5 cannot be accurately identified with a one atmosphere sample. In this case, alternative sampling methods such as absorption columns or drawing pressurized sample shall be used. Refer to PSNSY IPI 0558-839 for examples of acceptable procedures used to draw pressurized and unpressurized gas samples. For information on absorption column sampling, contact an appropriate technical activity such as the Naval Research Laboratory (NRL), Naval Submarine Medical Research Laboratory (NSMRL).

F.3.5.1 Unmanned DSS Atmospheric Testing

The primary purpose of unmanned DSS off-gas testing is to verify that when installed in the final configuration, the combined off-gas impact of all non-metallic material does not result in an unsafe atmosphere. Unmanned DSS off-gas testing shall be performed for the following events.

a. Initial Certification. For initial certification, unmanned atmospheric tests shall be performed at one atmosphere and at maximum manned pressure. Prior to initiating the tests, each space shall be loaded-out with all applicable non-metallic material such as mattresses, breathing masks and hoses. The contractor shall include all Contractor Furnished Equipment, but may exclude Government Furnished Equipment at the approval of the Program Manager and SCA. During unmanned atmospheric testing for initial certification, electrical devices such as displays, environmental control systems, carbon-dioxide removal blowers, shall, where possible, be energized, and remain energized throughout the test. During the test, every effort shall be taken to maintain the ambient temperature at the upper operational limit.

(1) For one atmosphere off-gas tests, the applicable space shall be isolated for 24 hours or 100 percent of the maximum anticipated closed-hatch mission duration. Where the space cannot be isolated for the desired time, because of schedule or other constraints, with Program Manager and SCA approval, the applicable allowable limits specified in Section F.5 shall be reduced proportional to the decrease in sample time. For example, if the maximum closed-hatch mission duration is 12 hours, but the test is run for only 6 hours, the applicable allowable contaminant limits specified in Section

F.5 shall be reduced by 50 percent. Be advised, that based on Section F.2.2, the results from one atmosphere testing are not corrected for SEV unless the space can be pressurized by varying its floodable volume. In this instance, the sample shall be SEV corrected to the maximum manned pressure caused by the reduction in floodable volume.

(2) For pressurized off-gas tests, the applicable space should be isolated at the appropriate pressure for not less than 4 hours. The results of the pressurized off-gas test shall be reviewed by medical and engineering department personnel against the off-gas data obtained from the breathing gas test, breathing gas system test and one atmosphere test to determine if the pressure is causing release of a contaminant either not previously identified or at a concentration higher than expected. Prior to performing the pressurized off-gas test, it is recommended that the applicable space(s) be pressurized, held at pressure for 30 to 60 minutes, depressurized, ventilated, and then pressurized for the test. This procedure eliminates the majority of off-gas contaminants that are often released from paints, resins and foams during first time exposure to pressure, and increases the probability that the pressurized test will be satisfactory.

(3) Testing to support evaluation of carbon-dioxide removal equipment at maximum manned depth shall be as specified in F.3.2.

b. Maintaining Certification. The Sustaining Activity/Fleet Maintenance Activity/industrial facility shall recommend, for Program Manager and SCA approval, as appropriate, unmanned tests as described in paragraph F.3.5.1.a above following major overhauls, repainting of interior surface areas (atmospheric sampling is not required if the repainting of the manned area involves less than 10 percent of the surface or it is an open loop ventilation system, the paint is of the same type already in use and approved for that specific application and the qualified paint has been cured in accordance with the paint schedule or as approved by NAVSEA), installation of untested non-metallic material, installation of new material, or installation of newly designed carbon-dioxide removal equipment. Testing following these events may not require the same level of testing performed for initial certification. Tests for maintaining certification should be modified to target the individual concerns associated with the event requiring the test.

F.3.5.2 Manned DSS Atmospheric Testing

The purpose of manned atmospheric testing is to validate the performance of all life support equipment including normal and emergency oxygen systems, carbon dioxide removal equipment, and heating, ventilation and cooling equipment in each manned space. As a condition of approval by the Program Manager and of certification by the SCA, the results of any manned testing shall be accepted by appropriate engineering and medical department personnel.

a. Initial Certification. Manned testing for initial certification shall only be performed after appropriate medical and engineering department personnel have reviewed and accepted the results of applicable unmanned tests. Manned testing for initial certification shall be performed in accordance with an integrated test approved by the Program Manager and SCA. The manned test shall be performed at one atmosphere and at maximum manned depth for a time equal to normal mission duration, or as otherwise approved by Program Manager and SCA. The manned test shall be performed with the design or maximum number of anticipated occupants. The buildup and distribution of carbon dioxide shall be monitored by instruments contained within the DSS system. Portable analysis equipment, including detector tubes, should be used during the manned test to monitor carbon monoxide level, and to monitor the presence of reactive gases such as ozone, ammonia, sulfur dioxide, hydrogen sulfide, and oxides of nitrogen (NO_x). If a suspicious odor or irritation of eye or mucous membranes is observed, tests for reactive gases should be made immediately. Notation should be made of any suspicious odors, eye irritants, and aerosols detected and appropriate action taken.

b. Maintaining Certification. The contractor or user shall recommend, for Program Manager and SCA approval, as appropriate, manned tests following any maintenance or modification that system operational testing demonstrates a significant change in the baseline performance of any life support equipment. The baseline performance shall be the initial certification manned test or last manned test, whichever is more recent. If manned testing is determined to be necessary, the initial certification or last performed manned test should be modified to target the individual concerns associated with the affected life support system.

F.4 CONTROLLING AND MONITORING NON-METALLIC MATERIAL

The items most likely to introduce an unknown or toxic contaminant into the DSS atmosphere, and similarly most difficult to control, are non-metallic materials installed in the DSS or used in the DSS during production and maintenance. During the construction of a DSS, hundreds of different non-metallic materials are used. The risk of a non-metallic material contaminating the DSS is very dependent on the chemical and physical properties of the material, and its age. In general, non-metallic materials that contain high vapor pressure components such as solvents and paints; materials that slowly cure such as fiberglass and adhesives; materials that are flexible and contain inaccessible areas such as rubber hoses; and materials that have internal voids such as foams have historically released toxic contaminants into DSS. Other materials, such as low vapor pressure fluorinated greases, plastics, and fabric have generally been very stable with little or no off-gas constituents at normal DSS operating temperatures and pressures.

F.4.1 Non-Metallic Material List

In order to identify and ultimately control the risk of non-metallic material contaminating the DSS, a list of all non-metallic materials should be developed. The list ultimately supports the Toxic and Flammability List addressed in Chapter 3, and

should identify all non-metallics installed into the DSS manned space during production, maintenance and repair. The list should categorize each non-metallic material as either Plastic, Fabric, Rubber (hose or gasket), Foam, Paint, Lubricant (oil or grease), Solvent, Cleaning Agent (other than solvent), Resin, Adhesive, or Other. The list should identify the material by chemical and trade name nomenclature, and for items installed within the DSS, identify the location by compartment or system, and the approximate total quantity or volume installed in that compartment or system. For electrical components comprised of multiple non-metallic materials, the list should identify the applicable electrical component, and then list the non-metallic materials associated with the insulation, housing, display screen, circuit boards, transformers and major capacitors.

F.4.2 Non-Metallic Material Off-Gas Testing

Non-metallic material should be off-gas tested prior to installation. Material can be off-gas tested in the installed configuration. However, considerable risk is assumed in this case since the origin of any unacceptable contaminants may not be readily identifiable. Considerable effort may be required to identify the material causing the problem. The following is a basic summary of the off-gas procedure, and shall not be considered conclusive.

a. Place a sample of material (measured in grams) or an assembly in a chamber of known volume (measured in liters). A sample to volume ratio of about 1 to 4 grams per liter is desired. The sample to volume ratio shall account for the pressure in the chamber.

(1) Materials which are essentially two dimensional such as films, coatings, primers, paints, tapes, labels, and thin film lubricants shall be applied to a carrier or substrate. Substrates shall be metal or glass to reduce distortion of test results.

(2) Materials which are essentially three dimensional such as foams, plastics, and rubber shall be tested as close to the end use configuration as possible.

(3) Liquids shall be placed in a sample container such as a petri dish.

b. Heat the chamber to the maximum manned or unmanned (transport) temperature for a recommended 24 hours, but not less than 4 hours. The chamber can be pressurized up to about 50 psig during the test to support sampling and analysis. When testing foams, pressurize the chamber to the maximum compartment pressure.

c. Sample/analyze the chamber for constituents as specified in Section F.5. The test results shall indicate absolute ppm values. Additionally, for items tested as a complete assembly, such as a computer, results shall be recorded in ppm/liter. For items tested as a specific material, such as a piece of foam, results shall be normalized and recorded as ppm/gram/liter.

Material that fails the off-gas test based on comparison with limits as specified in Section F.5 should be evaluated by engineering and medical department personnel for possible acceptance by performing a volume or mass loading calculation. This reviews the impact to the individual DSS space of the total mass of the item installed in that space in relation to the total volume or mass of all non-metallic materials in that space. Re-testing or replacement with a different material, assembly or vendor should also be considered.

F.4.3 Non-Metallic Material Off-Gas Test Report

Non-Metallic Material off-gas test reports shall, as a minimum, record the following data:

a. Testing facility name, address, and phone number.
b. Date material tested.
c. Lot or batch number of material.
d. Material chemical name.
e. Manufacturer of material.
f. Sample weight.
g. Sample surface area.
h. Pressure and volume of test chamber.
i. Temperature of test chamber.
j. Total time specimen was in chamber before chemical analysis.
k. Signature and date of test director.
l. Test results:

(1) List of constituents analyzed or identified.
(2) Method of analysis used to analyze constituent (see Table F-5).
(3) Allowable limit of each constituent (see Section F.6).
(4) Reporting limit for each constituent (see paragraph F.5.4.c).
(5) Absolute measured level of each constituent.
(6) Normalized measured level of each constituent (ppm/L or ppm/g/L – see paragraph F.4.2.c)
(7) Evidence of odor before and after the test.
(8) Curing procedure (when attempting to qualify product per Section F.4.4).

The non-metallic material off-gas test reports shall be evaluated in accordance with Section F.6. All off-gas test reports will be retained and maintained in a manner suitable for audit. Non-metallic off-gas test reports that are used to qualify a specific material or are being used in lieu of the testing specified in Section F.5.5 must be submitted to the Program Manager for approval and will be maintained to support DSS certification.

F.4.4 Non-Metallic Material Qualification

Non-metallic material routinely replaced because of maintenance or repair should be qualified as specified in this section to minimize repeated off-gas testing. Qualification

establishes a minimum cure time or cure procedure necessary to pass an odor test and then verifies the validity of the odor test by satisfactorily passing an off-gas test.

Qualification is applicable only to a material or assembly manufactured or processed by a specific vendor. Most non-metallic materials are blends of different chemical compounds with each vendor often having their own formula. Therefore, the off-gas characteristics of similar non-metallic material from different vendors can be dramatically different, even though physical characteristics are equivalent. To determine whether qualification is required, evaluate the non-metallic material using the following criteria:

a. Approved fluorocarbon plastics, elastomers, greases and high viscosity oils do not require qualification since they are inherently compatible because of their composition. Examples of approved fluorocarbon materials are Teflon, 3M Kel-F, DuPont Vespel, Diakin Neoflon, Viton, PTFE greases such as DuPont Krytox 240AC per MIL-G-27617, and CTFE greases such as Halocarbon Products 25-5S.

b. Thermosetting structural plastics are generally subject to one time vendor qualification. These types of non-metallic materials generally do not off-gas after manufacture since the lack of voids in the material and manufacturing method eliminates significant off-gassing constituents. Examples include Delrin (copolymer only), Nylon and Lexan.

c. Paints, adhesives, and lubricants, not otherwise specified, should be qualified for use based on a minimum cure time and a maximum applied volume or weight.

d. Resilient and resin setting non-metallic materials are generally subject to initial vendor qualification and subsequent lot sampling. These types of materials often off-gas considerably after manufacture. Examples include life-support hoses, fiberglass and blown foams. Life-support hoses are difficult because much of the surface is inaccessible. Fiberglass can be difficult because of variances in material thickness and resin-hardener ratios. Blown foams can be particularly difficult since there are many methods used to produce foam including use of nitrogen and refrigerant blowing agents such as HCFC-141b.

F.4.4.1 Initial Qualification Process

The non-metallic qualification process shall be as follows:

a. Determine the material vendor, and cure date or manufacturing date.

b. Test the material for odor by two people in accordance with the general guidelines of ASTM D1292. The acceptance criterion is no detectable odor. If an odor is detected, continue to cure the material until there is no odor detected. Record the cure time and cure procedure (if applicable) required to yield no detectable odor.

c. Off-gas the material as specified in Section F.4.2.

F.4.4.2 Vendor Qualified Materials

In-kind replacement of non-metallic materials identified as vendor qualified as defined by paragraphs F.4.4.b and F.4.4.c require no individual off-gas testing or post installation off-gas testing provided the following conditions are satisfied:

a. The material is properly cleaned such that the surface meets the applicable cleaning standard. In the absence of a specific cleaning standard, the surface should be visually free of oil, grease, mold release compound, cleaner residue and any other organic contaminant.

b. Material is provided by a vendor previously qualified as specified by F.4.4.1. This is not required for gaskets and seals purchased in accordance with accepted military or commercial specifications.

c. The material cure time and cure procedure (if applicable) has been satisfied. Cure time is not applicable to approved lubricants; Teflon, 3M Kel-F, Diakin Neoflon and DuPont Vespel plastics (commonly used in valve seats); and o-ring gaskets.

d. A check for odor using the guidelines of ASTM D1292 by two people yields no detectable odor.

F.4.4.3 Lot Sampled Materials

In-kind replacement of non-metallics defined by paragraph F.4.4.d identified as requiring lot sampling, such as foam, fiberglass, and life-support hoses, require no individual off-gas testing of each item or post installation off-gas testing provided the following conditions are satisfied. The concern with foams, fiberglass and life-support hoses is inherent manufacturing variations coupled with inaccessible areas that can trap or contain gaseous contaminants.

a. The material originates from a lot from which a sample off-gas tested satisfactory.

b. The material is properly cleaned such that the surface meets the applicable cleaning standard. In the absence of a specific cleaning standard, the surface should be visually free of oil, grease, mold release compound, cleaner residue and any other organic contaminant.

c. The material cure time and cure procedure (if applicable) has been satisfied.

d. A check for odor using the guidelines of ASTM D1292 by two people yields no detectable odor.

F.5 IDENTIFYING CONTAMINANTS

The most difficult part of a DSS Breathing Gas and Atmospheric Sampling Plan is selecting target compounds. Target compounds are those contaminants that, based on the factors and information addressed in Sections F.2 and F.3, are possible and require monitoring to ensure a safe atmosphere. Ideally, all contaminants from any source would be monitored. However, there are hundreds of possible contaminants. Both the NASA Space Shuttle and Submarine Atmospheric Monitoring Programs have identified over 150 possible contaminants from materials and processes common to these types of platforms. However, identifying every contaminant in every sample is cumbersome, costly and very time consuming; and may not significantly effect the decision as to the safety of the atmosphere. Historically, DSS have not implemented identification of all contaminants, but instead identified only target compounds because of the following factors.

a. DSS mission durations have generally only been a few days. In comparison, fleet submarines and space stations have design mission durations in excess of 30 days. Additionally, longer duration DSS, such as saturation platforms, have such strict design guidelines regarding non-metallic material use, that significant contamination from these materials has generally not been a major problem.

b. DSS projects have had only very limited industrial, laboratory and life support capability. In comparison, submarines have extensive power plants, life support equipment, water purification, sanitary, and food preparation capability. Shuttle and space stations have similar capability with the additional complication of extensive laboratory capability.

c. DSS projects have been manufactured in accordance with strict detail and performance requirements and specifications. Materials and processes that have previously caused problems such as solvents, paints, resins, lubricants, foams and hoses have been carefully controlled or eliminated during the design phase. Additionally, very few non-metallic materials that off-gas continuously are installed in DSS. Those that are have generally off-gassed very low levels of contaminants that have been further diluted by the volume of the DSS manned space.

d. DSS projects monitor all installed non-metallic material. The subsequent Toxic and Flammability list, addressed in Chapter 3, has allowed early review of material to prevent inadvertent installation of hazardous material.

The reader is cautioned that changes to the factors previously addressed may require expanding the monitoring of contaminants from target compounds to all compounds. DSS designs that address only performance requirements need to be especially sensitive to the ability to control contaminants. A DSS design controlled by detailed material specifications, with a breathing gas and atmospheric sampling plan

based on target compounds, may not be applicable to a DSS design controlled only by performance requirements. Limited disclosure of the materials and processes used in the manufacture of commercial off-the-shelf (COTS) items increases the risk of introducing unknown contaminants.

F.5.1 Physical Nature of Contaminants

Airborne contaminants may be a gas, vapor, liquid (aerosol), or solid (particulate). Some common terms used to describe airborne gases, vapor, liquids and solids are specified in Table F-1.

Except for the case of alkaline salt or carbon dust due to inadequate filtration of CO_2 absorbent canisters or activated charcoal filters (respectively); dust and fumes have not been a concern with DSS atmospheres during normal operation. However, casualties such as a fire, can release significant quantities of gases, vapor, dust and fumes. The toxicological effects, however, are mitigated by the use of emergency breathing systems.

Table F-1. Airborne Contaminant Terms

Common Term	Physical Form	Units of Measure	Explanation
Gas	Gas	vol/vol = ppm wt/vol = mg/m^3	molecules unrestricted by cohesive forces
Vapor	Gas	vol/vol = ppm wt/vol = mg/m^3	the volatilized form of liquids or solids
Mist	Liquid	wt/vol = mg/m^3	suspended liquid droplets typically formed when a volatilized liquid condenses
Fume	Solid	wt/vol = mg/m^3	suspended solid particles formed following condensation of material from a volatilized solid such as welding fumes
Dust	Solid	wt/vol = mg/m^3	suspended solid particles typically associated with various manufacturing processes such as grinding and grit blasting

F.5.2 Medical Effects of Contaminants

The effects of a contaminant on the human body defines the relative toxicological risk. The relative toxicological risk associated with exposure to a specific contaminant is defined by the route of exposure, dose, toxic potential (potency) of the contaminant, and inherent susceptibility of the host target organ to toxic insult. For the purposes of DSS, inhalation is the route of contaminant entry into the body which is of primary concern. While other routes of introduction are possible, such as ingestion and skin absorption, these routes are not considered to have been major concerns in the past. The following two categories define the major toxicological risks associated with contaminants.

a. Acute Toxicity. - Exposure to a contaminant at or above a specified concentration can result in physiological effects immediately or shortly after the exposure occurs. Toxic effects experienced can range from life threatening such as death by asphyxiation or cardio-pulmonary collapse, to incapacitating conditions such as convulsions, to simple irritation as evidenced by coughing and tearing eyes. In general, the physiological effects associated with acute exposure subside when the individual is removed from the contaminant, although prolonged or delayed effects are possible.

b. Chronic Toxicity. - Long term physiological effects can result from exposure to a contaminant at or above a specified concentration. Examples of chronic effects include cancer, lung disease, nerve damage, and skin irritation (dermatitis).

The effects of specific chemical compounds on the human body are well documented in many established medical and industrial hygiene references, and appropriate medical department personnel should be contacted for specific direction and guidance in this regard. However, one particular hazard to DSS, and unique to removing carbon dioxide from air using caustic alkaline salts is the decomposition of certain partially halogenated hydrocarbons into extremely toxic dichloroacetylene. Dichloroacetylene (CAS 7572-29-4) has an ACGIH Ceiling Limit of 0.1 ppm. The reported LC_{50} for inhalation by mice is 19 ppm after 6 hours exposure. Incidents of over-exposure to dichloroacetylene have noted headaches and excessive vomiting as initial symptoms followed by anesthesia and paresthesia. In instances where death occurred, symptoms consistent with encephalitis were noted. The following two common solvents in the presence of moderately heated alkali, such as the exothermic absorption of carbon dioxide by alkaline salts, can form dichloroacetylene: trichloroethylene and 1,2-dichloroethylene. The following two solvents are known to similarly decompose to another potentially toxic compound - monochloroacetylene: vinylidene chloride, and 1,1,1-trichloroethane.

Because of the extreme toxicological hazard associated with dichloroacetylene and monochloroacetylene, all precursor compounds are restricted from use within the DSS. Any use of the precursor compounds for manufacture of equipment to be installed

within the DSS shall be reported to the Program Manager and SCA, and is subject to their approval. Additionally, to protect DSS personnel from the effects of dichloro- and monochloroacetylene, the precursor compounds specified in Table F-2 shall be included as target compounds when sampling any DSS breathing gas, breathing gas system, compartment, or non-metallic material.

Table F-2. Dichloro/Monochloroacetylene Precursor Compounds

Precursor Compound	CAS No.	Allowable Exposure Limit
Trichloroethylene	79-01-6	0.1 ppm, max
1,2-Dichloroethylene	540-59-0	0.1 ppm, max
Vinylidene Chloride	75-35-4	0.15 ppm, max
1,1,1-Trichloroethane	71-55-6	2.5 ppm, max

F.5.3 Target Compound Lists

Each contractor or user shall develop lists of target compounds that take into account the unique type of sample and characteristics of each DSS. Target compound lists shall be developed for each of the following four types of samples:

a. Breathing Gas Sample. The list of target compounds shall conform to the applicable breathing gas requirement as specified in F.3.3.

b. Breathing Gas System Sample. The list of target compounds shall be consistent with the allowable contaminants in the gas used to pressurize the system, and the cleaning agents used to clean the system. Table F-3 lists target compounds for breathing systems cleaned in accordance with MIL-STD-1330 and MIL-STD-1622. For systems not cleaned in accordance with these standards, the contractor or user shall develop an appropriate list, and obtain Program Manager and SCA approval.

c. DSS Atmospheric Sample. Table F-4 is a list of target compounds that have been routinely identified during sampling of DSS atmospheres. The contractor or user shall review the list and select those compounds that are appropriate to the specific DSS. Where off-gas testing of non-metallic material has identified a compound(s) not listed in Table F-4 and below the applicable total halogen or total hydrocarbon screening limit of Table F-4, the contractor or user shall modify the atmospheric target compound list accordingly to include additional target compounds. Additionally, if the DSS integrates with a fleet submarine, the contractor or user shall modify the atmospheric target compound list to account for contaminants that can originate from

the fleet submarine, but are not listed in Table F-4. The reader is referred to NAVSEA S9510-AB-ATM-010, Nuclear Powered Submarine Atmosphere Control Manual, for information on fleet submarine contaminants. Whenever possible, unmanned atmospheric samples taken during initial certification should be analyzed to identify all detectable chemical compounds. This will provide a baseline from which follow-on sampling to maintain certification can be optimized to minimize impact and cost. Using the results from the unmanned initial certification gas analysis tests, to support maintenance of certification, the screening limits in Table F-4 for total hydrocarbons and total halogens can be lowered to reduce the number of target compounds below the screening limit that are individually analyzed.

d. Non-Metallic Material Sample. Initial sampling of non-metallic material should analyze for and identify all detectable gaseous contaminants. In the absence of that capability, the contractor or user shall use the list of atmospheric target compounds in Table F-4. The contractor or user shall review the composition of the material being tested and its method of manufacture, against the list in Table F-4 and select all compounds that are appropriate. The contractor or user shall modify the list as necessary to account for compounds not listed in Table F-4 and below the applicable total halogen or total hydrocarbon screening limit of Table F-4, but considered possible because of the composition of the material or its method of manufacture. When non-metallic material will be vendor qualified as specified in F.4.4, the user may wish to lower the screening limits for total hydrocarbons and total halogens to reduce the number of target compounds below the screening limit that are analyzed individually. Additionally, for non-metallic material that is being qualified for lot sampling as specified in F.4.4, the initial qualification sampling results should be used to lower, in subsequent samples, the screening limits for total hydrocarbons and total halogens. This will reduce the number of target compounds below the screening limit that are analyzed individually during lot sampling.

F.5.4 Target Compound List Approval

The Program Manager and SCA shall approve all target compound lists. Each list shall specify the following information.

a. The chemical, common commercial name (if applicable), and Chemical Abstracts Service (CAS) Registry Number shall be provided for each compound.

b. The Allowable Exposure Limit for each compound or group of compounds shall be specified. Allowable exposure limits shall account for both SEV correction and the health risk associated with extended exposure and exposure to multiple contaminants having similar toxicology (see Section F.6). In the absence of an established exposure limit, appropriate medical department personnel shall be consulted. If the SEV correction results in a limit below instrument detectability, the allowable exposure limit shall be specified as non-detectable.

c. The Reporting Limit for each compound or group or compounds shall be specified. The reporting limit is the lowest concentration (sensitivity) to which each compound, or group of compounds, must be analyzed. The reporting limit should be not less than one-fifth the SEV corrected allowable exposure limit. Where the SEV corrected allowable exposure limit is less than or equal to the instrument sensitivity, the reporting limit shall be specified as instrument detectability. The minimum instrument detectability, using the most sensitive analytical device, shall be equal to the SEV corrected allowable exposure limit, or if greater, a value acceptable to cognizant medical department personnel.

An exception to the information requirements of target compounds lists is when the sample is analyzed for all detectable compounds. In this case, the contractor or user shall identify, for Program Manager and SCA approval, the analysis methods to be used and the reporting limit or sensitivity for each analysis. Table F-5 lists common analysis methods used when analyzing gaseous contaminants. The analysis method used will be very dependent on the required target compound sensitivity. Very often, combinations of the various analysis methods will be used.

F.5.5 Breathing Gas System and Manned Space Off-Gas Test Report

Off-gas test reports of DSS breathing gas systems and manned spaces shall, as a minimum, report the following data:

a. Sample origin - organization and/or platform and/or system.
b. Pressure of system/compartment and gas used for testing.
c. Date sample drawn.
d. Unique number identifying the sample.
e. Sample container type, size, and pressure.
f. Analysis facility name, address, and phone number.
g. Date sample tested.
h. Signature and date of test director.
i. Analysis results:

    (1) List of target compounds analyzed or compounds identified.
    (2) Method of analysis used to analyze compounds (see Table F-5).
    (3) Allowable limit of each compound (see Section F.6).
    (4) Reporting limit for each compound (see Section 5.4.c).
    (5) Absolute measured level of each compound.
    (6) SEV correction, if applicable.
    (7) Any evidence of odor.

F.6 EVALUATING OFF-GAS AND ATMOSPHERIC ANALYSIS RESULTS

When evaluating the analysis results from breathing gas systems, manned spaces and non-metallic material, consideration must be given to the health risk associated

with exposure to contaminants for extended duration, as well as exposure to multiple contaminants which may be toxicologically similar. The limits specified in Tables F-3 and F-4 for individual target contaminants have been adjusted to account for the health risk associated with extended duration exposure. The adjusted limits also mitigate the health risk of exposure to multiple contaminants.

When evaluating the health risk of contaminants not listed in Tables F-3 and F-4, such as when the screening limits for total halogens or total hydrocarbons are exceeded, the SEV corrected concentration of each individual contaminant shall not exceed one of the following:

a. The 90 day limit specified by the Nuclear Powered Submarine Atmosphere Control Manual, or

b. The appropriate mission day limit specified by NASA JSC 20584 Spacecraft Maximum Allowable Concentration for Airborne Limits, or

c. One-tenth of the lowest allowable exposure limit established by OSHA or ACGIH.

As an example: SEV corrected total hydrocarbons are greater than 25 ppm. Analysis identifies (in addition to adjusted compounds previously analyzed) 10 ppm Acetone, 30 ppm Isopropanol, and 4 ppm Toluene. Since the concentration of each contaminant is less than one-tenth its OSHA or ACGIH allowable exposure limit, the analysis results would be acceptable.

When the screening limits for total halogens or total hydrocarbons are exceeded, or a compound is detected and quantified which cannot be evaluated as specified in F.6.a through F.6.c, appropriate engineering and medical personnel review shall be performed, and Program Manager and SCA approval obtained.

F.7 LABORATORIES PERFORMING ANALYSES

Only laboratories accepted by NAVSEA, or its designated representative, shall analyze breathing gas system, DSS atmosphere, or non-metallic material off-gas samples. Additionally, only laboratories accepted by NAVSEA, or its designated representative, shall perform non-metallic material off-gas tests. In addition to understanding the requirements specified herein, acceptance shall be dependent on the laboratory demonstrating quality assurance practices consistent with the provisions of ANSI/ASQC Q2, Quality Management and Quality System Elements for Laboratories - Guidelines; or ASTM E548, General Criteria Used for Evaluating Laboratory Competence; or equivalent.

Table F-3. Breathing Gas Systems Target Compounds

Constituent	CAS No.	Limit	Comments
Oxygen	7782-44-7	See Note 1	
Carbon Dioxide	124-38-9	See Note 1	
Carbon Monoxide	630-08-0	10 ppm, max	See Note 2
Total Hydrocarbons (expressed as, and including, methane)	NA	25 ppm	See Notes 2 & 3. Source – solvents, paint, plasticizer, oil, & grease.
Benzene	71-43-2	0.1 ppm, max	See Note 2
Methanol	67-56-1	7 ppm, max	See Note 2
Total Halogens (chlorinated, brominated & fluorinated compounds)	NA	10 ppm, max	See Notes 2 & 4. Source – solvents & refrigerants
1,1,1 Trichloroethane (methyl chloroform)	71-55-6	2.5 ppm, max	See Notes 2 & 5. Source – solvent.
Vinylidene Chloride	75-35-4	0.15 ppm, max	See Notes 2 & 5. Source - solvent.
Trichloroethylene	79-01-6	0.1 ppm, max	See Notes 2 & 5. Source - solvent.
1,2-Dichloroethylene	540-59-0	0.1 ppm, max	See Notes 2 & 5. Source - solvent.
Aerosols & Odor	NA	Non-Detectable	Visual & Olfactory

Table F-3. Breathing Gas Systems Target Compounds (Cont'd)

Notes:

1. The concentration shall be in accordance with the gas used during the off-gas test.

2. Correct the limit for Surface Equivalent Value (SEV) by dividing the limit by the maximum operating pressure of the manned space corrected to atmospheres absolute. When the limit is below instrument sensitivity, the analyzing activity shall report results as less than the applicable instrument detectability. The minimum instrument detectability, using the most sensitive analytical device, shall be equal to the SEV corrected allowable exposure limit, or if greater, a value acceptable to cognizant medical department personnel.

3. Measurements exceeding the Total Hydrocarbon screening limit shall require additional analysis to determine the causative constituents. One of the methods specified in Section F.6 shall be used to evaluate the health risk of any non-target compound.

4. Total halogen measurements shall express results in accordance with an accepted equivalency constituent such as chloromethane. Measurements exceeding the Total Halogen screening limit shall require additional analysis to determine the causative constituents. One of the methods specified in Section F.6 shall be used to evaluate the health risk of any non-target compound.

5. The limit specified is based on the potential for decomposition to dichloro- or monochloroacetylene in carbon dioxide removal equipment.

Table F-4. DSS Atmospheric Target Compounds

Constituent	CAS No.	Limit (See Note 1)	Comments
Inorganic Compounds			
Oxygen	7782-44-7	See Note 2	
Carbon Dioxide	124-38-9	See Note 2	
Carbon Monoxide	630-08-0	10 ppm, max	Source – organic decomposition
Ammonia	7664-41-7	10 ppm, max	See Note 3, Source - metabolic & insulation
Hydrogen	1333-74-0	10,000 ppm, max	See Note 4, Source – metabolic & battery
Sulfur Dioxide	7446-09-5	1.0 ppm, max	See Note 3, Source – metabolic & waste
Hydrogen Sulfide	7783-06-4	1.0 ppm, max	See Note 3, Source – metabolic & waste
Chlorine	7782-50-5	0.1 ppm, max	See Note 3, Source - potable water
Mercury	7439-97-6	0.01 mg/m^3, max	See Note 3, Source – electronic displays
Organic Screening Analyses			
Total Hydrocarbons (expressed as, and including, methane)	NA	25 ppm, max	See Note 5.
Total Halogens (chlorinated, brominated & fluorinated compounds)	NA	10 ppm, max	See Note 6.
Odor & Aerosols	NA	None Detectable	Visual & Olfactory

Table F-4. DSS Atmospheric Target Compounds (Cont'd)

Constituent	CAS No.	Limit (See Note 1)	Comments
Halogenated Solvents			
1,1,1 Trichloroethane (methyl chloroform)	71-55-6	2.5 ppm, max	See Note 7.
Trichloroethylene	79-01-6	0.1 ppm, max	See Note 7.
1,2-Dichloroethylene	540-59-0	0.1 ppm, max	See Note 7.
Hydrocarbon Solvents			
Benzene	71-43-2	0.1 ppm, max	See Note 3, Source - solvents & smoking
Butyl-Cellusolve	111-76-2	2 ppm, max	See Note 3, Source - aqueous detergents
Xylene(s)	1330-20-7	10 ppm, max	See Note 3, Source - solvents & adhesives
Intentionally Blank			
Other Organic Compounds			
Acrolein	107-02-8	0.01 ppm, max	See Note 3, Source – smoking, varnish, & paper products
Formaldehyde	50-00-0	0.04 ppm, max	See Note 3, Source – insulation & varnish
Vinylidene Chloride	75-35-4	0.15 ppm, max	See Note 3 & 7, Source – insulation

Table F-4. DSS Atmospheric Target Compounds (Cont'd)

Notes:

1. Correct the limit (except oxygen and carbon dioxide) for Surface Equivalent Value (SEV) when sampling spaces whose floodable volume is variable, and material that will be installed in pressurized portions of a breathing gas system (see Section F.2.2). Correct for SEV by dividing the limit by the maximum operating pressure of the manned space corrected to atmospheres absolute (ata). When the limit is below instrument sensitivity, the analyzing activity shall report results as less than the applicable instrument detectability. The minimum instrument detectability, using the most sensitive analytical device, shall be equal to the SEV corrected allowable exposure limit, or if greater, a value acceptable to cognizant medical department personnel.

2. The concentration shall be in accordance with the gas used during the off-gas test.

3. The limit specified is lower than that specified by OSHA or ACGIH to account for the health risk posed by extended exposure and exposure to multiple contaminants.

4. The limit specified is one-quarter the lower explosive limit.

5. Measurements exceeding the Total Hydrocarbon screening limit shall require additional analysis to determine the causative constituents. One of the methods specified in Section F.6 shall be used to evaluate the health risk of any non-target compound.

6. Total halogen measurements shall express results in accordance with an accepted equivalency constituent such as chloromethane. Measurements exceeding the Total Halogen screening limit shall require additional analysis to determine the causative constituents. One of the methods specified in Section F.6 shall be used to evaluate the health risk of any non-target compound.

7. The limit specified is based on the potential for decomposition to dichloro- or monochloroacetylene in carbon dioxide removal equipment.

Table F-5. Gaseous Contaminant Analysis Methods

Analysis Method	Comment
Electro-chemical	Interaction of an electrochemical cell with the target compound causes a proportional change in electrical output. Commonly used to monitor oxygen and carbon monoxide.
Ultraviolet Light (UV)	Ultraviolet light absorption of a target compound is measured by a UV spectrophotometer. This method has been used to detect mercury.
Colorimetric	Interaction of a target compound with a reagent solution causes a change in the reagent color that is proportional to the target compound concentration. The color change is measured with an optical spectrophotometer. This method has been used to detect formaldehyde.
Gold Film	Interaction of a target compound with a thin gold film that is part of a piezoelectric sensor causes a change in electrical resistance that is proportional to the target compound concentration. This method has been used to detect mercury.
Thermal Conductivity	Interaction of a target compound with a thermal filament cools the filament causing a change in electrical resistance proportional to the target compound concentration. This analysis method generally has not been sensitive to very low levels (<500 ppm), but has been used to detect hydrogen gas at relatively high levels.
Flame Ionization Detector (FID)	Combustion of target volatile organic compounds with hydrogen release ionized carbon that is collected by a platinum electrode. The change in electrode current is proportional to the number of ions being generated and subsequently collected. Commonly used with PID analysis to determine groups of organic compounds such as Total Hydrocarbons.
Photo-Ionization Detector (PID)	Target volatile organic compounds are ionized with UV light. The change in ion current is proportional to the target compound concentration. Commonly used with FID analysis to determine groups of organic compounds such as Total Hydrocarbons.

Table F-5. Gaseous Contaminant Analysis Methods (Cont'd)

Analysis Method	Comment
Infrared Spectro-photometer (IR)	The absorption of infrared light by target compounds is measured with an infrared spectrophotometer. Specific compounds can be identified by the selective absorption of infrared radiation at specific wavelengths -- often referred to as an IR signature. Depending on the sophistication of the IR device, method can be useful in qualitatively and quantitatively identifying many compounds. Can be tuned to monitor for specific compounds such as carbon dioxide. Use of a Fourier Transform IR devices greatly increases sensitivity.
Gas Chromato-graph (GC)	Sample gas is injected into a column that separates the individual compounds by retaining selective compounds at different time periods. At the outlet of the column will be various detectors such as FID, PID, Electron Capture, and MS. Based on the retention time for the type of column used, and the type of detector, individual compounds can be identified and quantified. Gas chromatography is very sensitive with detection limits in the ppb.
Mass Spectrometer (MS)	The mass spectrometer produces charged ions consisting of the parent ion and ionic fragments of the original compound. The ions are differentiated by their mass to charge ratio. In combination with GC, the MS is used to identify individual compounds in a gas sample containing numerous compounds.

F.8 FLAMMABILITY TESTING

Materials shall be evaluated based on their ability to withstand burning. Manufacturer's flammability data shall be reviewed to determine material acceptability. If data is not conclusive the materials shall be tested and evaluated to determine if a material, when exposed to a standard ignition source will self-extinguish and not transfer burning debris, which can ignite adjacent material. If testing differing from the requirements of Section F.8.2 is desired, NAVSEA approval is required. Evaluation shall be in accordance with a specification approved by the Program Manager with SCA concurrence. Acceptance criteria should be dependent on the intended use of the material; however, Table F-6 is provided for guidance.

F.8.1 Flammability Test Equipment

For material to be used in environments normally maintained at one atmosphere, no elevated oxygen environments are required to be used.

For material to be used in other than one atmosphere environments, the maximum oxygen concentration permitted in the DSS shall be used. The test shall be conducted at both one atmosphere and at the actual pressure the system is to be used.

Table F-6. Acceptance Criteria

Flammability Test Results	Acceptability
Material Sample Tested	
Material does not burn or immediately self extinguishes when removed from flame	Acceptable without further review.
Material continues to burn after removal from flame, but self extinguishes prior to complete combustion.	Acceptable with NAVSEA review and approval. Submit quantitative and qualitative test results. Provide proposed quantities and locations of material.
Material burns to completion after removal from flame.	Requires NAVSEA review and approval. Submit quantitative and qualitative test results. Provide proposed quantities and locations of material.
Material generates sparks or embers which could serve as a source of ignition	Requires NAVSEA review and approval. Submit quantitative and qualitative test results. Provide proposed quantities and locations of material. Provide mitigating rationale for installation.
Complete Assembly Tested	Document information required by this appendix. Submit to NAVSEA for review and approval.

F.8.2 Material Sample Test Documentation Requirements

The report format and arrangement are at the discretion of the testing activity. If a commercial specification is used to conduct testing, it shall be identified; however, the following data, as a minimum, shall be recorded:

a. Testing contractor name, address, and phone number.
b. Date material tested.
c. Lot or batch number of material.
d. Manufacturer's material name.
e. Manufacturer of material.
f. Sample size (length, width, height, or diameter).
g. Test fuel used and burn temperature.
h. Test results.

(1) Does material burn after removal of flame? (yes/no)
(2) Does material self extinguish after removal of the flame but prior to complete combustion? (yes/no)
(3) If material burns record the total burning time. (seconds)
(4) Color of flame.
(5) Description of the products of combustion.
(6) If drippings are present, do they burn (ignition of K-10 paper)?
(7) Description of the type and amount of smoke produced.

i. Signature and date of test director.

F.8.3 Alternate Procedure for Complete Assemblies

Flammability testing of a complete equipment assembly would result in destruction of the unit. To avoid loss of equipment but still allow a valid assessment of flammability, the following alternative analysis shall be conducted.

a. If possible, identify types and amounts of all materials used in the assembly. Evaluate commercial flammability data for these materials, if available.

b. If the equipment is energized when operating, it must be built in accordance with a recognized commercial specification (i.e., MIL-SPEC, UL, etc.).

c. If the equipment is energized when operating, perform a 24 hour "burn in bench test" to determine the maximum temperature the energized unit reaches. Identify any local hot spots.

d. Determine if assembly is mounted next to any other installed heat sources. This should be avoided if possible, but if not, address how the assembly will be

protected from these heat sources (e.g., insulated with a nonflammable material such as NOMEX®) and assess the impact of colocation.

e. Determine if the assembly is a heat source itself. If so address how surrounding areas will be protected.

f. If the assembly is energized, operators must be able to de-energize the hardware quickly to eliminate power to the heat source.

g. Result of the analysis shall be forwarded to NAVSEA for review and approval.

APPENDIX G

GENERAL GUIDELINES FOR CLEANING BREATHING GAS SYSTEMS

G.1 INTRODUCTION

This appendix provides general guidelines for cleaning Navy man-rated DSS breathing gas systems. Examples of breathing gas systems in this category are metabolic oxygen, air, helium-oxygen, and nitrox.

These general guidelines address the issues associated with the cleaning of life support systems, and convey the experience of those knowledgeable in cleaning breathing gas systems. Failure to conform to accepted practices can result in the introduction of or failure to remove toxic and flammable contaminants that can cause catastrophic equipment failure and personnel injury and death.

G.2 REFERENCES

G.2.1 Military Standards

MIL-STD-1246 - Product Cleanliness Levels and Contamination Control Program

MIL-STD-1330 - Precision Cleaning and Testing of Shipboard Oxygen, Helium, Helium-Oxygen, Nitrogen, and Hydrogen Systems

MIL-STD-1622 - Cleaning of Shipboard Compressed Air Systems

G.2.2 Commercial Specifications

ASTM G93 - Standard Practice for Cleaning Methods for Material and Equipment Used in Oxygen-Enriched Environments

CGA G-4.1 - Cleaning Equipment for Oxygen Service

NFPA 53M - National Fire Protection Agency Chapter 53M, Fire Hazards in Oxygen-Enriched Atmospheres

SAE AIR 1176 - Oxygen System and Component Cleaning and Packaging

G.2.3 Other

NAVSEA 00C4-PI-002, Cleaning Diving System Air Components With Navy Oxygen Cleaner (NOC)

NAVSEA 00C TOPSIDE TECH NOTES, Volume VI, Issue 1, of Oct 95, Diver Life Support System Cleaning

Puget Sound Naval Shipyard Industrial Process Instruction (PSNSY IPI) 0558-839, Life Support Gas Systems; Cleaning and Inspection Procedures/Testing Criteria

G.3 SYSTEM AND COMPONENT CLEANLINESS CONCERNS

Cleanliness of Life Support Systems (LSSs) and components is a critical attribute and is related to controlling the presence of organic, particulate and moisture contamination. Each contaminant presents a unique, but overlapping hazard.

a. The presence of organic contamination can lead to a fire from adiabatic compression or particle impact. Compressing a gas from 0 to 3000 psig can generate gas temperatures of over 1500°F. Depending on the quantity of a specific contaminant and the breathing gas, the fire hazard from organic contamination can range from remote in low pressure air to highly probable in high pressure oxygen. The resultant fire can ignite surrounding elastomers, and may also ignite or melt through metallic materials depending upon the breathing gas. Oxygen systems are particularly hazardous since all organic materials including any oil and grease, Teflon, and Viton can burn in 100 percent oxygen at atmospheric pressure. Additionally, thermal decomposition of organic contaminants can lead to the formation of highly toxic by-products including carbon monoxide from the decomposition of hydrocarbon oil, hydrogen-fluoride from the decomposition of fluorocarbon lubricants, and phosgene from the decomposition of some chlorinated solvents.

b. The presence of particulate contamination can lead to a fire or equipment failure from fouling or wear. Individual large particles or groups of smaller particles can effect component operation, especially pressure regulators. Large particles traveling at high velocity upon impact can release sufficient energy to ignite themselves, as well as surrounding organic contamination, rubbers and plastics. Particle impact is particularly hazardous in high pressure oxygen systems where the impact energy needed to ignite organic material can be 100 times less than in a similar air system. The reader is directed to NFPA 53M for additional information regarding fire hazards in oxygen-enriched atmospheres.

c. The presence of moisture contamination can lead to component failure from freezing or corrosion. The expansion of a gas as it flows through a pressure regulator can develop temperatures well below 0°F. Small passages combined with excessive moisture can lead to partial or complete blockage with ice. Large gas storage flasks are often manufactured from alloy steel that, in the presence of excessive moisture, can lead to rust and the subsequent release of small particles.

G.4 CLEANING METHODS AND MATERIALS

The following comments amplifying the requirements are derived from experience gained in cleaning breathing gas systems.

G.4.1 Approved Cleaning Agents

Only cleaning agents approved by MIL-STD-1330 or MIL-STD-1622 shall be used for final cleaning of breathing gas systems. Cleaning agents approved by MIL-STD-1330 and MIL-STD-1622 have been carefully evaluated for flammability, toxicity, material compatibility and performance.

Many commercial cleaning agents contain organic material whose residue is toxic in breathing gas systems, or is flammable in oxygen and high pressure air. Residue from common aqueous detergents such as Non-Ionic Detergent per MIL-D-16791 are flammable in oxygen. Likewise, common industrial solvents such as Trichloroethylene are flammable in gaseous oxygen and highly toxic to breathing gas systems.

An additional concern with cleaning agents is the potential reaction with regenerative life support systems. Closed-loop life support systems often employ chemicals to remove carbon dioxide generated from the metabolic consumption of oxygen. A common carbon dioxide removal chemical is Lithium Hydroxide. Some partially chlorinated solvents such as Trichloroethylene and Methyl Chloroform in contact with Lithium Hydroxide can dehydrochlorinate generating dichloroacetylene, an extremely toxic compound.

G.4.2 Cleaning Processes

Successful application of a cleaning agent to obtain a desired level of cleanliness can only be achieved when used in accordance with a validated cleaning process. MIL-STD-1330 and MIL-STD-1622 specify validated cleaning processes. Each contains sufficient information and data to easily develop a cleaning process suitable to the local organization.

For an example of a fully detailed cleaning process containing the requirements of MIL-STD-1330, the reader is directed to PSNSY IPI 0558-839. Other MIL-STD-1330 and MIL-STD-1622 cleaning process information can be found in NAVSEA 00C4 Process Instruction 002, and NAVSEA 00C Topside Tech Notes Vol VI, Issue 1.

G.4.3 Commercial Oxygen Cleaning Specifications

The reader is cautioned on using commercial oxygen cleaning specifications such as ASTM G93, CGA G-4.1, and SAE AIR 1176. These specifications often group all oxygen applications including non-life support applications such as brazing, rocket

propulsion and foundries under common requirements, and often address use of very flammable and toxic solvents.

Additionally, the reader is advised that commercial oxygen specifications verify oxygen cleanliness using surface verification techniques. In comparison, MIL-STD-1330 verifies oxygen cleanliness using process verification techniques. Experience has shown that process verification is more cost effective, with no reduction in cleanliness, if properly developed. In the case of MIL-STD-1330, the process was validated using surface verification techniques.

Commercial oxygen cleaning specifications may be used in place of MIL-STD-1330 with NAVSEA approval. Approval shall be based on whether the final cleaning agent is one of those approved by MIL-STD-1330, the surface is verified less than or equal to 3 mg/ft^2 non-volatile residue using a credible analytical technique, particulate meets MIL-STD-1246 cleanliness level 100, and the packaging, tagging, and cleanroom requirements are equivalent to MIL-STD-1330.

G.5 POST CLEANING GAS ANALYSIS

Any use of a solvent for cleaning an LSS or LSS components requires a post gas analysis to verify satisfactory removal of the solvent. Equipment for analyzing are at the discretion of the user. However, the equipment selected must be capable of detecting the specific chemical at a sensitivity low enough to verify removal of the solvent to the required level. Sampling and analytical techniques shall follow written procedures and all results shall be recorded. For an example of a fully detailed gas analysis procedure, the reader is directed to PSNSY IPI 0558-839. Use of a MIL-STD-1330 or MIL-STD-1622 aqueous cleaning process does not require post gas analysis. The aqueous processes specified by these standards use inorganic aqueous cleaners that have been verified not to off-gas. Appendix F provides additional guidelines for gas analysis of LSSs.

G.6 MAINTAINING THE SYSTEM IN A CLEAN CONDITION

G.6.1 Providing a Clean Gas

Care should be taken to provide a gas which is not contaminated with particulate. Although all gas is sampled for chemical purity, the particulate cleanliness of commercial storage flasks and gas transfer equipment is not checked. In order to prevent any contamination from entering the system during charging procedures, a 10 micron, or finer, filter should be installed immediately upstream of the charging connection. Experience has shown that failure to use filtration will most often result in the introduction of a fine dust which has lead to component wear.

G.6.2 Maintaining Cleanliness During Maintenance and Repairs

To prevent loss of cleanliness during routine maintenance and repairs, it is desirable to incorporate work procedures and analysis techniques that provide assurance that cleanliness has been maintained. Requisite work procedures and analytical techniques are specified in MIL-STD-1330 and MIL-STD-1622. At a minimum during the removal and replacement of components, maintain cleanliness during the repair or maintenance of a clean system by preventing the entry of foreign material. This will be accomplished by plugging or capping openings using methods as specified below. Prevent airborne contamination near exposed openings by minimizing evolutions such as grinding, painting, and brazing.

a. Plugs and external caps: Plug or cap openings using methods such as metal or rigid plastic covers, polyethylene or other bagging, threaded and non-threaded plugs and caps, expandable and nonexpandable wafer plugs, and inflatable plugs. Wipe caps or plugs with a clean cloth prior to use. Do not use a cap or plug if it can be completely inserted into the opening which it protects, without specific foreign material controls. Whenever installing a cap or plug, ensure that the seal is tight.

b. Closure with film: Apply film over openings. When choosing the film, consider items such as thickness, strength, sloughing resistance, and moisture permeability. Secure the film with tape taking care so that the tape does not contact the opening portions of the item.

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APPENDIX H

DESIGN GUIDELINES FOR DSS HANDLING SYSTEMS

H.1 INTRODUCTION

a. This appendix contains certification parameters for handling systems employed in the launch and recovery of manned DSSs from support ships. The methods of design and fabrication are discussed, and their required verification OQE is identified. Preventive maintenance documentation, which is influenced by, and evolved from the basic design concepts, as well as operational documentation is also outlined.

b. DSS handling equipment to be certified under these requirements includes, but is not limited to, cranes, booms, davits, and A-frames; plus their associated winching and rigging components. Hydraulic, electrical, and pneumatic subsystems are also considered part of the handling system.

c. All critical items, as defined in paragraph H.2.b, shall be included in the SOC. The SOC will also contain all items necessary to ensure compliance with the objective and intent of certification as described in Chapter 1.

d. Weight handling components may be included within the SOC of the DSS or a separate SOC can be developed to cover only the weight handling components. This latter case is applicable when a single weight handling system is used to support the operations of more than one DSS.

H.2 DEFINITIONS

a. Added Mass Effect. The mass of water particles surrounding an object immersed in water that is accelerated with the object as the object is accelerated through the water. When a body is accelerated in a fluid, it behaves as though its mass is greater than it actually is due to the effect of the surrounding fluid. This additional mass must be added to the actual body mass to account for the change in inertia.

b. Critical Item. Any item within a system, equipment, or component whose failure would endanger the occupants of the DSS. These failures may include uncontrolled dropping, shifting, or other sudden movement of the DSS when it is supported by the handling system.

c. Design Load. The maximum force due to the rated load plus some or all of the following: (1) added mass effects, (2) entrained water, (3) any external payloads, (4) drag or wind loads, and (5) dynamic loads which are derived with the aid of the dynamic load factor.

d. Dynamic Load. The load imposed on a system due to accelerations of gravity and ship motion. It is dependent upon the magnitude and frequency of ship motions, ship attitude, and the location of the handling system on the ship.

e. Dynamic Load Factor. A calculated number given in acceleration units, g, where 1g is the acceleration of gravity. The force exerted by the system on its supports is determined by multiplying the dynamic load factor by the weight of the system.

f. Fail-safe. Components within the handling system that are designed to prevent uncontrolled dropping, shifting, or sudden movement of the DSS during a hydraulic or electrical system failure or component/equipment malfunction.

g. Handling System. The mechanical, electrical, structural equipment and rigging used on board a support ship to launch and recover a manned DSS.

(1) Load Bearing. Those components of the handling system that support the loads resulting from launching and recovering of a manned DSS.

(2) Load Controlling. Those components of the handling system that position, restrain, or control the movement of a manned DSS. Towing is excluded from the SOC.

h. Rated Load. The maximum weight that may be lifted by the assembled handling system at its rated speed and under parameters specified in the equipment specifications (e.g., hydraulic pressures, electrical current, electrical voltages, etc.).

i. Rigging. Running rigging consists of the rope (wire rope or synthetic line) intended to handle the DSS that passes over sheaves or through rollers. Standing rigging is rope that is stationary and provides mechanical support to the handling system.

j. Static Test Load. A weight equal to 200 percent of the rated load of the handling system. It is used to physically verify the structural integrity of the handling system, and the adequacy of its brakes.

k. Support Ship. Any platform used to transport, launch, and retrieve a DSS. Ships, boats, vessels, barges, and submarines are included in this definition. An example of a submarine support platform is one modified to carry a Dry Deck Shelter for operations with Swimmer Delivery Vehicles.

H.3 DESIGN CRITERIA AND GUIDELINES

H.3.1 Equipment Design Criteria

This section provides guidelines and criteria for the design and analysis of DSS handling system components and associated structures within the SOC. Alternatively, the Program Manager may elect to impose commercial design criteria administered by

the American Bureau of Shipping (ABS). If the ABS Rules are used, the Program Manager must obtain initial certification for the handling system from ABS. Once ABS certification is obtained, the Program Manager shall use ABS to conduct periodic surveys.

H.3.1.1 Types of Loads

The initial step in designing any handling system is to determine the design load that the system will encounter. The design load is derived from a combination of forces under worst-case operating conditions. Components should be sized according to the greatest design load, or combination of loadings that will be encountered. The following loads and forces should be considered when designing DSS handling systems:

a. Asymmetric loads. When sizing structural members for handling systems which employ more than one load carrying member to support their payload, consideration should be given to factors which might cause asymmetric loading. Such factors affecting the DSS that would result in asymmetric loading include, but are not limited to, the following: external water, free surface effects in the internal tanks, a shift in ballast, and external payloads.

b. Dynamic loads. In addition to the load generated by lifting the normal rated capacity of the handling system, dynamic forces due to wave induced motions on the support vessel must also be considered. Analysis should be conducted in accordance with DOD-STD-1399, Section 301A or equivalent, unless support vessel motions are known. If support vessel motions have been measured at sea, or have been determined through the application of proven computer programs, the results can be used in lieu of DOD-STD-1399, Section 301A.

c. Dead loads. The minimum dead load consists of the weight of the structural parts of the DSS handling system and materials permanently attached to the structure.

d. Wind Forces. The wind loads on the projected area of the handling system structure and on the DSS, appropriate to the design conditions, are to be considered.

e. Maximum Forces. Structural members are to be sized using the appropriate loads and factors of safety. The general requirements in applying factors of safety to all U.S. Navy weight handling systems that perform manned lifts are presented in paragraph H.4.1.1.1 and Table H-1.

H.3.1.2 Environmental Considerations

DSS handling systems are subjected to extremely harsh and powerful environmental factors which significantly impact the operational and maintenance

characteristics of the system. Environmental factors which should be considered in the system design parameters are: sea state, air temperature, water temperature, precipitation (rain and snow), ice, wind velocity, currents, and the corrosive affects of the salt water environment.

H.3.1.2.1 Sea State

For the operational sea state specified, the uppermost value for the wave heights of the significant wave or the 1/10th highest wave should be taken as the design wave. The period of maximum energy of the sea spectrum should be chosen as the design period.

H.3.1.2.2 Air and Water Temperature

The maximum and minimum design operating temperatures of both the air and water must be taken into account during handling system design. This is particularly important for hydraulic systems where hydraulic fluid may become too viscous in extreme cold or lose its lubricating properties in extreme heat. Additionally, extremely cold air temperatures may affect the ductility of some metals and render structural members unsafe if not adequately designed.

H.3.1.2.3 Precipitation

The effect of rain and snow can be dramatic on topside equipment not designed for it. Electrical connectors, junction boxes and motors which are not rated for harsh outside environments often fail in shipboard service. All pivoting or sliding load bearing surfaces should either be sealed from the weather or be designed to permit thorough inspections and be provided with an adequate number of lubrication fittings. Waterproof grease is required for these applications. Also, steels must have a protective coating of paint designed for a sea water environment.

H.3.1.2.4 Wind Velocity

Side loads may be induced in the handling system by high winds. This loading may be significant if either the DSS or the handling system itself has a large surface area. The prudent designer will account for possible wind related effects in the system design.

H.3.1.2.5 Ocean Currents

In the same manner that wind affects the handling system topside, ocean currents affect any submerged components of the DSS. Drag effects caused by ocean currents may be significant depending on the geometry of the DSS and/or any submerged portions of the handling system. Drag effects must be taken into account in the design of the handling system.

H.3.1.2.6 Corrosion

Each component should be carefully reviewed for its susceptibility to corrosion, with special attention given to those components immersed in salt water. Furthermore, care should be taken to avoid galvanic corrosion when several different kinds of metals are in physical or electrical contact. Galvanic series charts or tables should be consulted when utilizing dissimilar metals.

H.3.1.3 System Considerations

The operation of the handling system is an integral part of the total DSS, and as such, is limited by the coordination of personnel on deck and interface of the DSS, handling system, and support vessel. For safe and efficient launch and recovery evolutions, the following items should be considered when developing a DSS handling system:

a. Positive Control. The motion of the DSS during launch and recovery operations must be under positive control at all times.

b. Fail-Safe. A provision designed to automatically stop or safely control any motion when a failure occurs. The DSS handling system shall be provided with interlocks, safety devices, and protective devices so that it will be fail-safe.

c. Motion effects. The physical location of the handling system on board the support ship should be such that the effects of the ship's motions on the DSS during handling evolutions are minimized.

d. Weight. The weight of the DSS handling system should be minimized to limit the weight added to the support vessel and the adverse effects on its sea keeping ability.

e. Shock mitigation. Dynamic motions of the support ship at-sea can cause shock loads to the DSS and its personnel through the handling system. Motion compensating devices shall be considered to minimize these shock loads.

H.3.2 Human Engineering and Operational Design Considerations

DSS handling systems are designed to transport personnel in a restricted and hazardous environment under the direct supervision and control of support personnel. A human engineering evaluation shall be conducted to maximize the support personnels' ability to control and supervise the safe, efficient, and timely movement of the DSS. The following are some critical areas which should be addressed in the evaluation:

a. Hazardous exposure. Due to the nature of handling system operations, some evolutions will be inherently hazardous. However, hazards should be eliminated whenever possible. There should be a minimum of support personnel exposed to hazardous operations during handling evolutions. There should be minimal diver/swimmer involvement during launch and recovery of the DSS.

b. Coordination and control. Safe and timely operation of handling systems requires precise control and coordination of all personnel involved. The system arrangement should facilitate simplicity and minimal supervision to attain this goal.

In addition, there must be clear communications between the DSS handling support personnel and the support ship personnel responsible for maneuvering the ship.

c. Monitoring equipment status. Control and support personnel responsible for the operation of the handling system should have access to monitoring devices to enable them to evaluate the status of the equipment. This is to ensure the system is operating within its capability limits (e.g., speed, load, pressure, temperature, etc.). These factors, along with the observed sea state, can then be evaluated to determine their effect on the operating parameters of the DSS.

d. Manning. From both an operational and maintenance approach, the number of personnel and their respective training levels are important design parameters that should be considered.

H.3.2.1 Emergency Conditions and Reduced Operating Capability

The DSS handling system shall be designed to minimize the effects of component failures. To identify and define the failures, and to determine how to resolve them, a system safety analysis shall be performed in accordance with MIL-STD-882, System Safety Program Requirements, or an approved industrial standard. The system safety analysis can also be used to evaluate the system's capability to continue to operate and safely recover DSS personnel. All handling system components shall be operable in sea states specified by the mission profile. In the event of a control console failure, an alternate or backup means of system operation is required.

H.4 DESIGN AND TESTING REQUIREMENTS

a. This section covers the design and testing of DSS handling systems. NAVSEA review requirements are also presented. Alternatively, the Program Manager may elect to impose commercial design and testing criteria administered by ABS. If the ABS Rules are used, the Program Manager must obtain initial certification for the handling system from ABS. Once ABS certification is obtained, the Program Manager shall use ABS to conduct periodic surveys.

b. Load bearing component requirements are discussed in Section H.4.1, and cover structural, rigging, and machinery component criteria; hydraulic and pneumatic system requirements are discussed in Section H.4.2; and power requirements and controls are discussed in Section H.4.3.

c. Design analyses for DSS handling systems must be based on recognized engineering analytical methods and standards. Loads imposed by the environmental conditions specified in the requirements documentation must be included in the analyses. The design of all load bearing and load controlling elements that are within the SOC boundaries must be submitted to NAVSEA for review and approval.

H.4.1 Load Bearing Component Requirements

All elements of the handling system that support the weight of the DSS when occupied by personnel shall be designed, fabricated, and maintained in accordance with the following requirements:

H.4.1.1 Load Bearing Component Design

a. Design analyses must indicate forces, loads, shears, and moments for all structural members, welds, and connections including interaction forces with the supporting deck and ropes. Components shall be analyzed considering tensile, compressive, bending, shear, and torsional loadings. Structural members subject to pure compression shall be evaluated in accordance with either DDS-100-4 or AISC Manual of Steel Construction, Specifications and Codes. (Note that the allowable stresses and safety factors used therein shall be revised as required to meet the safety factors specified in Section H.4.1.1.1). Analyses for rigging gear must also be included in the design documentation.

b. Calculations shall take into account the wet and dry weight of the DSS, entrained water weight, added mass effects (if applicable), crew and payload weights, the dynamic affects due to the motion of the support ship and DSS at sea, and the effects of the wind forces. The support ship's motions shall be analyzed for the maximum operating sea conditions, sea state or swells specified in the requirements documentation. The worst-case loading due to heave, roll, pitch, or any combination thereof, shall be used in the calculations.

H.4.1.1.1 Design Factors of Safety

Factors of safety for DSS handling systems are based on Navy engineering practices, and are related to the material used and the conditions of the operating environment. Relatively high safety factors are necessary, even though the materials and their properties are well known, because they are used in uncertain environments and are subjected to uncertain stresses. Material justification will be required in accordance with Appendix A to certify handling system components within the SOC,

even when the design meets the requirements of this section. Items requiring material justification will be identified during the conceptual design phase and during initial certification meetings.

a. Structural and machinery components.

(1) For surface support ships, the factor of safety for all structural and machinery components shall be 2.5 on material yield strength, or 4 on material ultimate tensile strength; whichever is greater.

(2) For submarine support ship applications, the factor of safety shall be 3 on material yield, or 5 on material ultimate tensile strength; whichever is greater.

The above factors of safety shall be based on the design load.

b. Rigging and Fittings.

(1) Factors of safety for wire and synthetic rope are given in Table H-1. These factors shall be based on the design load of the DSS handling system and the specified nominal breaking strength for wire rope or average breaking strength for synthetic rope.

(2) If galvanized wire rope is used, reduce the nominal breaking strength by 10 percent to account for the effects of galvanizing.

NOTE: If drawn galvanized wire is used, no reduction in breaking strength is necessary.

(3) Rope break test. Each rope is to have a certificate of break indicating the load at which the test sample broke. The break test for synthetic fiber line shall be in accordance with FED-STD-191, ASTM D4268, or the Cordage Institute Standard Test Method for Fiber Rope. The break test for wire rope shall be FED-SPEC-RR-W-410D, Wire Rope and Strand, or an approved industrial standard. OQE must be provided to relate the rope(s) purchased to the certificate of break test. In addition, the certificate of break test shall indicate the date of test, rope size, number of strands, number of wires per strand, quality of wires, and the load at which the test sample broke.

(4) When used with wire or synthetic rope, the factor of safety for fittings shall be equal to or greater than the commercial rating for the DSS design load.

Table H-1. Factors of Safety for Rigging

Material Application	Critical Component	Noncritical Component	D/d Ratio[1]
Wire rope standing rigging	5	5	-
Wire rope running rigging	6	5	18:1
Rotation resistant wire rope			
- standard construction	7[2]	6	34:1
- formed through a die	6	5	18:1
Synthetic rope[3]			
- Braided	7	5	8:1
- Twisted/Plaited	7	5	10:1
- Aramid (kevlar)	6	5	20:1

[1] Ratio of sheave or drum diameter (D) to wire rope or synthetic line diameter (d).

[2] This factor of safety is for rotation resistant wire rope supporting a free hanging load. If a guideline system is used that does not allow the load to rotate, this factor of safety can be reduced to 6. Under no circumstances shall the factor of safety for wire ropes be less than 6 for manned lift systems.

[3] When wet, the safety factor for nylon rope shall be applied to the breaking strength minus 15 percent unless a suitable marine overlay finish is used.

H.4.1.2 Submission of Drawings and Calculations for Load Bearing Components

Designs of DSS handling systems shall be submitted to NAVSEA for review and approval. As a minimum, the following material shall be submitted:

a. Design analyses and calculations that provide the basis for the system design, including all assumptions governing the design. The analyses must include the following when results of computer calculations are submitted: input data, summaries of input and program assumptions, output data, and summaries of conclusions drawn from the output data.

b. General arrangements showing equipment locations and the rated capacity of the system.

c. Details showing sizes, sections, and locations of all structural members.

d. Details of all reeving components showing sizes, safe working loads, materials, manufacturer, and part number.

e. For synthetic rope: length, size, material, construction, average breaking strength, manufacturer, and specification (if applicable).

f. For wire rope: length, size, construction, preformed or non-preformed, lay, finish, grade (IPS, EIPS, or traction steel), core type, lubrication, and manufacturer.

g. Foundation and support arrangements.

h. Structural material specifications.

i. Drawings must show all welding proposed for the principal parts of the structure. The welding process, filler metal, and joint design are to be shown on detail drawings or in separate specifications.

j. The areas to be nondestructively inspected and methods of inspection are to be shown on the drawings, or in separate specifications.

k. Winch drum details.

l. Type and size of bolts.

m. Reeving diagram.

n. Testing requirements and procedures.

o. List of all materials and fittings, for all components.

p. The components within the SOC must be identified.

H.4.1.3 System Testing for Load Bearing Components

a. All new DSS handling systems must be tested prior to initial certification and operational use. In addition, all modified or extensively repaired handling systems shall be inspected and tested in accordance with paragraph H.4.1.3.d(5). These tests are intended to confirm the adequacy of the design, the operational characteristics, and the validity of the operating procedures. For modified or repaired systems, the purpose of these tests is to verify the adequacy of the work performed, and to ensure the handling system continues to meet its design and certification criteria.

b. All DSS handling systems shall have static, dynamic, and rated load tests conducted on the following occasions: after being installed on a support ship, upon completion of an overhaul, and at intervals not to exceed 5 years. The 5 year interval is meant to coincide with support ship overhaul or availability periods. In addition, a static load test, dynamic load test, rated load test, or a no-load test shall be accomplished, as required, after repair or replacement of system components in accordance with paragraph H.4.1.3.d(5).

c. Test procedures for all load tests and System Operational Tests (SOTs) shall be submitted to NAVSEA for review and approval.

d. The following paragraphs identify the requirements for conducting static, dynamic, and rated load tests. In addition, maintenance testing requirements after completing maintenance tasks are also addressed.

(1) Static Load Test. A static load test physically verifies the structural integrity of the fully assembled DSS handling system. Test loads may be applied with certified test weights or by mechanical devices with calibrated load measuring gages.

(a) The static test load shall be equal to 200 percent of the rated load of the handling system, and shall be held for a minimum of ten minutes. No evidence of structural or rigging component deformation, or brake slippage is allowed. Upon completion of the static load test, the critical load bearing components and strength welds of the handling system shall be inspected to verify there is no permanent set, deformation, cracking, or other damage to any part of the structure, foundations, machinery, and reeving components. For initial certification, or if load bearing component repair or modification work was accomplished, the level of inspection shall be as specified on the drawings or in separate specifications to include MT or PT as applicable. End fittings on ropes included in the test shall be inspected for slippage and damage.

(b) The static load test shall be conducted when the support ship is pier-side and experiencing no significant motion. The handling system shall be tested in the position of maximum loading.

(2) Dynamic Load Test. A dynamic load test demonstrates the capability of the DSS handling system to operate with the rated load under the dynamic conditions of the support ship's motions at sea. The test shall demonstrate the handling system's overload capabilities throughout its complete operating range. Care must be taken to ensure specific operating limits of the components being tested are not exceeded.

(a) The dynamic load test shall be equal to 150 percent of the rated load of the handling system. Test loads shall be moved through one complete cycle of the handling system, with all limits of its operating modes (raising, lowering, traversing, traveling, rotating, etc.) included in the test. The handling system, with the test load, shall be stopped at least three times in each direction to ensure proper brake operation. No speed is specified; however, the maximum speed attainable with the test load shall be used.

(b) During the dynamic load test, the handling system shall be checked for any signs of binding, abnormal noise or vibration, and overheating. As a minimum, the following equipment parameters shall be recorded during the test: motor amperage, hydraulic fluid temperatures and pressures (including main loop, servo, and

replenishing pressures), operating speeds for all modes of operations (i.e., booming out, booming in, and/or raising and lowering, etc.). In general, the following shall be verified and noted: smooth operation, and proper stopping and holding of the test weight.

(c) Upon completion of the dynamic load test, the handling system shall be inspected for any indications of the following: warping or permanent deformation; leaking hydraulic fluid from any component or connections; wear patterns on sheaves, ropes, and gear trains; and proper drum spooling.

(d) The dynamic load test shall be conducted when the support ship is pier-side and experiencing no significant motion.

(3) Rated Load Test. A rated load test demonstrates the capability of the DSS handling system to operate with its intended load at its rated speed. It also verifies that all hydraulic and electrical components operate within their specified operating limits.

The rated load test shall be equal to 100 percent of the rated load of the DSS handling system. Test loads shall be moved completely through the handling system's full operating range, and within limits of all operating modes (raising, lowering, traversing, traveling, rotating, etc.). The system shall be capable of hoisting the DSS at the system's rated speed when the hoist wire rope or synthetic line is on the outermost layer of the drum. The test load shall be run through at least three cycles to demonstrate proper operation. Each cycle is to be run at the specified normal operational speed of the handling system.

(4) No Load Test. No load tests are conducted to evaluate the functioning of the DSS handling system. The DSS handling system shall be operated through its full range of motions and directions. Check for unusual noise, vibration, or overheating in machinery and control components. Also check for proper operation of all indicator lights and gages.

(5) Maintenance Testing Requirements. Conducting the full range of load tests (i.e., static, dynamic, and rated load tests) is not always necessary after completing corrective maintenance actions or some repair tasks. The following table identifies the tests required after performing various tasks on structural, rigging, or machinery components. Some handling systems have unique components and may require additional or modified testing. The test documents for those tests shall be submitted to NAVSEA for review and approval on a case basis. The System drawings/specifications should be consulted for further testing requirements. The tests specified below and the applicable test specified by a drawing or specification shall be conducted for each maintenance task identified. If there is a conflict between the tests specified below and the test specified by the applicable drawing or specification, then the requirements of this document take precedence, unless specifically authorized by the Program Manager.

Table H-2. Maintenance Testing Requirements - Load Bearing Components

Maintenance Task	Test Requirements
1. Drum or sheave repair, replacement, or modification	Static load test,[1] Dynamic load test, Rated load test
2. Hook[2] repair, replacement, or modification	Static load test[1]
3. Main lift rope(s) replacement (wire rope and synthetic line)	Pull test,[3] No-load test
4. Coupling, shaft, or bearing repair or replacement	Dynamic load test, Rated load test
5. Non-load bearing shafts or bearing repair or replacement	No-load test
6. Gear repair and replacement (load bearing or load controlling only)	Static load test,[1] Dynamic load test, Rated load test
7. Gear bearing oil-seal replacement	No-load test
8. Hydraulic cylinder repair or replacement (when the cylinder is used to support the weight of the Deep Submergence Vehicle, as in the case of an A-frame and elevator)	Static load test,[1] Dynamic load test, Rated load test

[1] Only the repaired, replaced, or modified component needs to be statically load tested. If the affected component can be rigged such that the 200 percent test load can be applied to it only, then that test would suffice for the static load test.

[2] "Hook" in this document is a generic term for the interface device between the DSS and the handling system.

[3] All wire rope end fitting installations must be pull-tested to either 200 percent of the design load of the handling system, or to 40 percent of the nominal breaking strength of the wire rope. All synthetic line eye splices shall be proof tested to 200 percent of the design load of the handling system.

H.4.2 Hydraulic and Pneumatic System Requirements

Hydraulic systems shall be designed and tested in accordance with the requirements of this subsection. These requirements can also pertain to pneumatic systems; however, it is recommended that the Program Manager and NAVSEA discuss any unique requirements prior to initial design efforts.

H.4.2.1 System Design

a. Hydraulic and pneumatic systems and components shall be designed to operate the rated load at the rated speed when the differential pressure across the actuator is not more than two-thirds of the maximum operating pressure. This will ensure the handling system will operate efficiently under dynamic conditions at sea as well as when undergoing load testing.

b. Hydraulic and pneumatic systems and components shall be designed in accordance with MIL-STD-2193, Hydraulic System Components, Ship; with piping, valves, fittings and gasket material selected from MIL-STD-777, Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships (or MIL-STD-438 for submarine applications), or an approved industrial standard. Naval Ship's Technical Manual Chapter 556, Hydraulic Equipment (Power Transmission and Control); Naval Ship's Technical Manual Chapter 505, Piping Systems; or Naval Ship's Technical Manual Chapter 551, Compressed Air Plants and Systems, can be used as guidance.

Hydraulic and pneumatic systems and components shall be designed such that they are fail-safe and the brake on any winches, traction machines, cranes, or elevators shall set and stop motion if there is a loss of power.

c. Program Managers may also elect to design the DSS Handling System in accordance with the requirements of Title 46, Code of Federal Regulations (CFR), Subchapter F, Marine Engineering, or an approved industrial standard. However, applicable parts and subparts of the commercial specification must be defined by the Design Agent and Program Manager and approved by NAVSEA prior to initiating the design.

d. Additionally, the following requirements shall also be met:

(1) The maximum operating pressure shall not exceed pump or compressor and motor manufacturer's continuous ratings.

(2) Pump or compressor drive electric motor current shall not exceed nameplate rating at the design load.

e. As a minimum, the following documents shall be submitted to NAVSEA for review and approval:

(1) Design analyses and calculations that provide the basis for the system design, including all assumptions governing the design. The analyses must include the following when results of computer calculations are submitted: input data, summaries of input and program assumptions, output data, and summaries of conclusions drawn from the output data.

(2) Plan showing manufacturer's ratings, braking capabilities and power drive requirements for hydraulic equipment.

(3) Plan showing details on emergency source of power.

(4) Hydraulic schematic that shows:

(a) Relief valve settings

(b) Material specifications, size, and pressure ratings of all pipe fittings, valves, flexible hoses, pumps, filters, and accumulators.

(c) Testing and cleaning requirements.

(5) Drawings and design calculations, or a COC from the manufacturer is required for each hydraulic or pneumatic cylinder to identify its burst pressure.

(6) Testing procedures.

(7) The components within the SOC must be identified.

H.4.2.2 System Testing

a. Hydraulic and pneumatic systems and components shall be tested in accordance with the requirements of this subsection. However, commercial Program Managers may test their DSS handling systems in accordance with the requirements of Title 46, CFR Subchapter F, Marine Engineering or an approved industrial standard. Applicable parts and subparts are to be defined by the Design Agent and Program Manager and approved by NAVSEA prior to initiating the design.

b. All test procedures for items within the SOC, including Factory Acceptance Test (FAT) procedures, shall be submitted to NAVSEA for review and approval.

H.4.2.2.1 Hydrostatic Testing Requirements

a. All new piping and pressure-containing components shall be hydrostatically tested. In addition, any piping, pressure-containing components, or tanks (accumulators, cylinders, etc.) that have been subject to repairs or modifications

affecting its structural integrity (such as welding, brazing, or reboring) must be retested to verify the integrity of its structure.

NOTE: Appendix J testing is not applicable to the handling system except as referred to in this appendix.

b. Hydrostatic test pressure for piping and piping components shall be 150 percent of maximum operating pressure. The pressure used to perform the test shall be within ± 3 percent (but no greater than 100 psig) of the designated test pressure, unless otherwise specified.

c. The duration of hydrostatic tests for pipe and piping components, including piece parts, conducted in a shop or on a test bench shall be not less than 5 minutes.

d. The duration of hydrostatic tests for pipe and piping components, including piece parts, conducted in the as-installed configuration shall be not less than 15 minutes soak time plus sufficient time for inspection of mechanical joints and components within the test boundaries.

e. Hydrostatic testing of hydraulic system piping should be performed with system fluid. However, water or other flushing fluids are permissible when accomplished in accordance with MIL-STD-419, Cleaning, Protecting, and Testing Piping, Tubing, and Fittings for Hydraulic Power Transmission Equipment or an approved industrial standard. Hydrostatic tests of installed systems shall be conducted with system fluid only. However, hydrostatic testing of pneumatic systems should be conducted with demineralized water.

f. For flexible hoses the hydrostatic test procedure and pressure shall be in accordance with paragraph 8.2 of NAVSEA S6430-AE-TED-010, Piping Devices, Flexible Hose Assemblies or an approved industrial standard.

g. Acceptance criteria for hydrostatic tests shall be no permanent deformation as determined by visual inspection. Leakage past mechanical joints or valve seats during the test shall not be cause for rejection as long as the test pressure can be maintained. However, any leakage shall be noted in the test results section of the test procedures.

H.4.2.2.2 System Tightness Testing Requirements

a. All new and repaired pipe and piping components shall be subjected to a tightness test prior to operating the system.

b. The tightness test pressure shall be 100 percent of the maximum operating pressure. The pressure used to perform the test shall be within ± 3 percent (but no greater than 100 psig) of the designated test pressure, unless otherwise specified.

c. The duration of tightness tests for pipe and piping components conducted in the as-installed configuration shall be not less than 15 minutes soak time at system operating pressures and temperatures, plus sufficient time for inspection of mechanical joints and components within the test boundaries.

d. Tightness testing should be conducted using system fluid.

e. Acceptance criteria for tightness testing of joints being accepted by the test shall be zero external leakage.

H.4.2.2.3 Maintenance Testing Requirements

The following table identifies system level tests required after performing various hydraulic system maintenance tasks. Some handling systems have unique components and may require additional or modified testing. The test documents for those tests shall be submitted to NAVSEA for review and approval. The CSP should be consulted for further testing requirements. The tests specified below and the applicable test specified by a drawing or specification shall be conducted for each maintenance task identified. If there is a conflict between the tests specified below and the test specified by the applicable drawing or specification, then the requirements of this manual take precedence.

Table H-3. Maintenance Testing Requirements - Hydraulic Systems

Maintenance Task	Test Requirements
1. Hydraulic pump or hydraulic motor repair or replacement	Dynamic load test, Rated load test
2. Servo valve, high pressure piping, and components repair or replacement	No-load test
3. Hydraulic Cylinder repair or replacement (when the cylinder is used to support the weight of the DSS)	Static load test, Dynamic load test, Rated load test
4. All other hydraulic system components and piping repair or replacement	No-load test
5. Major brake repair or replacement	Static load test, Dynamic load test, Rated load test
6. Routine adjustment or alignment of brake	No-load test

H.4.2.3 Relief and Counter-Balance Valves

Relief valves and counter-balance valves require special attention and shall meet the requirements of this section. The safety of DSS personnel depend on the proper operation of these valves. Relief valves are used in motion compensation circuits as well as for protecting the hydraulic system from over pressurization. Counter-balance valves are used to stop the DSS from moving uncontrollably in the event of a sudden loss of system pressure.

a. The following shall be accomplished for all new relief valves and counter-balance valves, and existing relief and counter-balance valves that have been subjected to repairs, modifications or corrosion that would affect the structural integrity of the valve. Prior to system operational use, they shall be:

(1) cleaned,

(2) seat tightness tested, and

(3) have their cracking pressure verified.

NOTE: Seat tightness testing and cracking pressure verification can also be accomplished after installation while the system is being adjusted.

b. The duration of seat tightness tests conducted in a shop or on a test bench shall be not less than 5 minutes. (See Section J.4)

c. The duration of seat tightness tests conducted in the as-installed configuration shall be based on the time necessary for the minimum leakage to be detected at the point of observation or monitoring.

d. Acceptance criteria for seat tightness testing shall be in accordance with applicable military or manufacturer's specifications, approved test documents, or as directed by NAVSEA.

e. The seat tightness test shall be conducted at a pressure equal to the maximum system operating pressure.

f. System fluid is the preferred test medium for seat tightness testing.

g. Cracking pressures shall be verified in accordance with system drawings or manufacturer's specifications.

h. Operating characteristics of relief valves and counter-balance valves shall be verified by either test bench methods or when adjusting the system during installation or maintenance.

H.4.2.4 Cleaning, Flushing, and Preservation

a. Cleaning, flushing, and preservation of hydraulic system piping and components shall be in accordance with ASTM D4174, Standard Practice for Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems, or an applicable commercial specification, subject to approval by the SCA. The maximum allowable particulate contamination level shall be specified on system drawings.

b. Cleaning and flushing of pneumatic systems shall be accomplished using best commercial practice and materially compatible cleaning agents to remove all loose scale, rust, grit, filings, oil and grease. The Program Manager shall submit for SCA approval, a list defining the compatibility of selected cleaning agent(s) with each system material.

c. If hoses are flushed with water before installation, they must be blown dry with dry air. Filtered system fluid should be used for flushing, rather than water, following the general guidance in MIL-STD-419 or an approved industrial standard.

H.4.3 Electrical Power Requirements and Controls

Attention should be given to each component's electrical power requirements in view of the total system power drain on the support vessel or independent power source. Two separate and independent power sources should be available to support the DSS handling system. When the design/configuration of the DSS dictates that the DSS must be lifted from the water in order for the DSS operator(s) to disembark, two separate and independent power sources shall be provided to support operation of the DSS handling system.

H.4.3.1 System Design

a. Design and installation of the handling system's electrical power distribution system shall be in accordance with the requirements of Title 46, Code of Federal Regulation (CFR), Subchapter J, Electrical Engineering, or an approved industrial standard.

Electrical systems and components shall be designed such that they are fail-safe and the brake on any winches, traction machines, cranes, or elevators shall set and stop motion if there is a loss of power.

b. The controls shall be service-proven state-of-the-art electronics, and meet U.S. Coast Guard regulations or other authoritative specification.

(1) All controls used during the normal handling system operating cycle shall be located within easy reach of the operator while at the operator's station.

(2) Control levers shall return automatically to their center (neutral) position when released.

(3) Control operations and functions shall be clearly marked and easily visible from the operator station.

c. Plans and information submitted to NAVSEA for review and approval shall be in accordance with Title 46, CFR, Subpart 110.25-1 of Subchapter J as determined to be applicable by the contractor and as approved by NAVSEA. If the design of the control system is not within the purview of Subchapter J, the appropriate plans and information broadly covered by Subchapter J, Subpart 110.25-1 shall be used as guidance for submission of control system plans and information to NAVSEA for approval. The components within the SOC must be identified.

H.4.3.2 System Testing

a. Electrical system and component testing and inspection shall be in accordance with Title 46, CFR, Subpart 110.30 of Subchapter J. Additionally, each major component shall have a COC that shows the component meets specific requirements acceptable to the Navy.

b. All test procedures for items within the SOC, including FAT procedures, shall be submitted to NAVSEA for review and approval.

c. As a minimum, the following tests shall be conducted after the DSS handling system is installed on board a support ship:

(1) Continuity and insulation resistance (IR) checks.

(2) System Operational Test (SOT)

H.4.3.2.1 Maintenance Testing Requirements

The following table identifies the functional tests required after performing various electrical system maintenance tasks. Some handling systems have unique components and may require additional or modified testing. The test document for these tests shall be submitted to NAVSEA for review and approval on a case basis. The CSP should be consulted for further testing requirements. The tests specified below and the applicable test specified by a drawing or specification shall be conducted for each maintenance task identified. If there is a conflict between the tests specified below and the test specified by the applicable drawing or specification, then the requirements of this document take precedence.

Table H-4. Maintenance Testing Requirements - Electrical Systems

Maintenance Task	Test Requirements
1. Power distribution system repair	Continuity checks, Insulation resistance checks, Voltage readings, No-load test
2. Electrical control circuitry adjustments, alignments, or repairs	No-load test
3. Electric motors for HPUs:	No-load test, Rated load test
4. Limit switch repair or replacement	No-load test

H.5 CERTIFICATION REQUIREMENTS

a. This section describes OQE necessary to achieve and sustain U.S. Navy certification. These requirements are in addition to those requirements identified previously in this appendix.

b. The certification process in Chapter 2 shall be followed. This appendix provides clarification to some of those requirements.

c. If the DSS Program Manager elects to use the services of ABS to conduct initial and/or sustaining certification surveys, this section may be used as a guide to ensure that all SCA certification issues are adequately addressed.

H.5.1 Initial and Sustaining Certification Requirements

The OQE and processes identified below are required for initial certification, reinstatement of certification, and sustaining certification. OQE for repaired, refurbished, or replaced items and material will be reviewed and evaluated during periodic (normally annual) sustaining certification surveys. Alterations to items within the SOC must have prior NAVSEA approval.

a. Design

The design of all items within the SOC shall be approved by NAVSEA. This includes calculations and/or drawings. In the design phase, for building or modifying a handling system, the information identified in the preceding sections of this appendix must be submitted to NAVSEA for review and approval. It is recommended that the Program Manager allow sufficient lead time for NAVSEA to complete its review, and to address any revisions before the working drawings are needed by the production shops. During the initial design phase, an initial design meeting should be held between the Design Agent, the Program Manager, the Cognizant Technical Authority and the SCA to get all groups working in the right direction.

b. Fabrication

(1) All fabrication, welding and inspection of material within the SOC shall be in accordance with the latest revision of NAVSEA S9074-AR-GIB-010/278, Requirements for Fabrication Welding and Inspection, and Casting Inspection and Repair for Machinery, Piping, and Pressure Vessels, or NAVSEA T9074-AD-GIB-010/1688, Fabrication, Welding, and Inspection of Submarine Structure, similar specifications for different materials, or an approved industrial standard.

(2) Commercial Sponsors may use the above military standards, or the ABS Rules for Building and Classing Steel Vessels or equivalent for welding procedures and welder qualifications. Nondestructive testing inspection is to be in accordance with the above military standards, the ABS Rules for Nondestructive Inspection of Hull Welds, or equivalent. The applicable portions of the commercial specifications which will be used for fabrication, repair, and maintenance of items in the SOC are to be defined by the Design Agent and Program Manager and approved by NAVSEA. This should be accomplished prior to the start of construction.

(3) The system shall be fabricated and installed in accordance with NAVSEA approved drawings and manufacturing processes. The components, materials, and system configuration of the handling system shall be in accordance with applicable drawings. The documentation shall provide verification that work has been accomplished in accordance with fabrication requirements. All fabrication records required by the fabrication specifications and drawings shall be completed, signed, dated, and available for review by the SCA prior to certification.

c. Material Control

(1) For load bearing components whose catastrophic failure would endanger the safety of DSS personnel, the industrial or maintenance facility, or Sustaining Activity, as applicable, shall implement a system to document the identity of tested and approved materials. Controls shall be established to ensure the correct materials and components were received and installed. OQE demonstrating that the correct materials were received and installed shall be retained as directed by the Program Manager.

(2) For all other material in the SOC, activities shall be able to demonstrate that all material used is in accordance with the specifications.

d. Quality Assurance

The Quality Assurance Program shall be a planned, documented, and have a systematic approach to all the actions necessary to provide adequate confidence that a handling system conforms to established technical requirements. The QA program shall contain provisions that result in recorded data related to:

(1) Organization

(2) Design and Drawing Control

(3) Material Control

(4) Fabrication and Manufacturing Control

(5) Technical Evaluation

(6) Personnel Qualifications

(7) Inspection

(8) Testing and Test Control

(9) Calibration

(10) Audits.

e. Ropes

(1) Information for synthetic ropes used to support the DSS shall include the following:

(a) fiber type
(b) size
(c) length
(d) average breaking strength
(e) construction.

(2) Information for wire ropes used to support the DSS shall include the following:

(a) size (diameter)
(b) length
(c) direction and type of lay
(d) nominal breaking strength
(e) construction and grade.

(3) Each new synthetic and wire rope is to have a certificate of break to ensure that the safety factor is as designed. The break test shall be in accordance with FED-STD-191, Cordage Institute Standard Test Method, or ASTM D4268 for synthetic ropes, and FED-STD-191 for wire ropes. The certificate of break must be furnished by the manufacturer, supplier, or applicant.

(4) Documentation must be provided to substantiate the above information for each synthetic or wire rope. In addition, OQE must be provided that traces the above information to the installed rope.

f. Testing

Test procedures for tests required by the applicable sections of this appendix shall be reviewed and approved by NAVSEA. All tests shall be satisfactorily accomplished. The results of the completed tests must be reviewed and found acceptable by the testing activity prior to NAVSEA certification.

g. System Maintenance

Critical components must be monitored for wear and deterioration by periodic inspections and scheduled maintenance. The Design Agent shall ensure that system and component maintenance requirements are incorporated into a maintenance plan. Maintenance plans and procedures must be reviewed and approved by NAVSEA prior to initial certification. After certification has been granted, any changes to the maintenance procedures or periodicities must also be reviewed and approved by NAVSEA. There shall be an auditable system of scheduling, performing and recording maintenance requirements established by the Sustaining Activity. There shall be a written maintenance, repair and replacement record of all items within the SOC.

h. Operational Demonstration

For initial certification, static, dynamic, and rated load tests, paragraphs H.4.1.3.d(1), (2) and (3) shall be witnessed by a NAVSEA representative.

i. Operating and Emergency Procedures

The Program Manager shall submit operating procedures and emergency procedures to NAVSEA for review and approval. This documentation must include: normal and emergency procedures, and pre-launch, launch/recovery and post recovery procedures and inspections. After certification has been granted, any changes to these procedures must also be reviewed and approved by NAVSEA. The procedures utilized shall be the procedures approved by NAVSEA. The completed procedures shall be retained for all handling evolutions.

j. Documentation

(1) Documentation for all repaired or refurbished items must include the following, as a minimum: (This satisfies the requirements of the work control section of Chapter 5). Appendix I should be used as guidance.

(a) Description of the work performed, the reason the work was accomplished, and verification that the work was performed in accordance with requirements.

(b) Description of any replacement parts, including the part number from the applicable drawing or manufacturer's brochure.

NOTE: COCs and invoices must also identify the part. The purpose of this data is to be able to ensure the replacement part is equal to or better than the part it replaced.

(c) Installation requirements (if applicable).

(d) Description of testing performed to ensure the system operates properly and is in accordance with its design parameters. Documentation shall provide verification that testing has been satisfactorily accomplished in accordance with the requirements.

(e) Documentation of work and testing shall be sufficient to relate the work, testing and replacement parts.

(2) Documentation of construction, maintenance and operations shall be retained. Operating records shall be retained on-board from survey to survey. Routine maintenance documentation shall be retained for three years or until re-performed, whichever is longer. Construction and maintenance documentation other than routine shall be retained until the documentation is superseded. The intent is to have all documentation on the current condition of the installed equipment.

k. Reports

Report all material casualties within the SOC, including launch aborts. Provide post casualty/mission abort/launch abort analysis, including recommended corrective action, to the SCA by the fastest means possible.

H.5.2 Certification Surveys

a. The initial certification survey will be in accordance with Chapter 4. The CSP for this survey will be developed in accordance with Chapter 2 and Appendix K.

b. DSS handling systems shall undergo periodic (normally annual) sustaining certification surveys to ensure maintenance, repairs, and operations have been performed in accordance with approved requirements. The survey will consist of three inspection categories: examination of all system logs or records, a visual inspection of the handling equipment, and a no-load test.

(1) The system logs or records to be reviewed include operating logs, maintenance logs, and training logs. The purpose of this part of the survey is to ensure that the operator is adequately conducting maintenance, repair, and replacement for all items within the SOC. It is also to ensure that launch and recovery operations and inspections have been performed safely and properly, and that handling system operators have been properly trained.

(2) The purpose of the handling system visual inspection and no-load test is to satisfy the surveyor that the system has been properly maintained and is in good working condition.

c. Survey Plans

(1) The survey plan at the end of this appendix, Figure H-1, can be used for conducting existing DSS Handling System periodic surveys. It may need to be revised to be used on a new system for periodic surveys.

With the exception of the valley break replacement criteria (for wire ropes), the rope inspection and replacement criteria tables, Tables 1 and 2 in Figure H-1, contained in this plan exist in other military specifications. As such, this is the governing specification for valley break replacement criteria only. The tables in this manual may not be updated as the other specifications change, however, the tables shall be updated when using this survey plan to conduct a periodic survey. This survey plan is considered to be already approved by the SCA.

(2) For other than periodic surveys after the initial certification survey, the CSP generated in accordance with Appendix K for the initial certification survey shall be utilized. The CSP shall be updated with all work accomplished since the previous survey. The updated CSP shall be submitted for review and approval by the SCA.

d. Prior to the NAVSEA survey, the activity is expected to conduct an internal survey to an internally generated survey plan, the CSP generated in accordance with Appendix K and updated as applicable, or in accordance with the survey plan at the end of this appendix.

H.5.3 Suspension of Certification

Certification may be suspended by the SCA when any of the following events cause a reduction in the material or procedural adequacy of the DSS handling systems:

a. Violation of any of the terms or conditions of certification;

b. Recognition of the existence of an unsafe condition; or

c. Overhaul or other major repair period.

The SCA will reinstate certification when the cause of the suspension has been thoroughly investigated, satisfactorily corrected, and the material and procedural adequacy of the system has been re-established.

Figure H-1. DEEP SUBMERGENCE SYSTEM (DSS) SUPPORT SHIP ANNUAL SURVEY PLAN

DSS SUPPORT SHIP NAME:_____
DATE OF SURVEY:_____ LOCATION:_____
SURVEYOR:_____ REVIEWED WITH:_____

System logs were reviewed starting from _____ (date of last survey) through _____ (date of the last time the DSS handling system was used. This could have been to launch and recover the DSS, or for maintenance or testing purposes.)

List the logs or records reviewed during this survey: (Review them in accordance with Parts I.A, I.B, and I.C - see next page)

(1)_____ sat/unsat

(2)_____ sat/unsat

(3)_____ sat/unsat

(4)_____ sat/unsat

(5)_____ sat/unsat

(6)_____ sat/unsat

(7)_____ sat/unsat

(8)_____ sat/unsat

_____
Auditors signature/Organization/Date

Figure H-1

I. EXAMINATION OF SYSTEM LOGS OR RECORDS

A. OPERATING LOGS/RECORDS

Review operating logs for the following:

(1) Completeness.	Have all steps requiring signatures been signed off? Are pre-launch, launch, recovery, and post recovery procedures and inspections complete?
(2) Consistency.	Are applicable entries, including dates, consistent with other logs?
(3) Discrepancies.	Are there any discrepancies related to abnormal operating conditions, or inoperability of any safety device or load controlling component noted in the logs? If so, were all discrepancies satisfactorily resolved prior to the next dive?
(4) Briefings.	Are there records of the pre-evolution briefings and watch station assignments?
(5) Procedures.	Ensure procedures and changes to procedures have been approved in writing by NAVSEA.

B. MAINTENANCE DOCUMENTS

Review maintenance logs for the following:

(1) PMS.	Ensure that periodic preventive maintenance is in progress. Ensure procedures and changes to procedures have been approved in writing by NAVSEA.
(2) Accountability.	Sample component accountability for maintenance on SOC items, including periodicity (i.e., ensure that manufacturer's maintenance requirements, including periodicity, are met).
(3) Inspections.	Have periodic inspections been performed?. Required inspections include daily (pre-operational and post-operational), weekly, and all other inspections listed in the documentation.
(4) Repair and Replacement.	Review records for any SOC items that have been repaired or replaced. Is there proper documentation to ensure the component is equal to what is required in the applicable drawing(s) (i.e., material and strength)? Was the component installed and tested properly? Have all material casualties been reported to NAVSEA?

Figure H-1 (Cont'd)

C. TRAINING RECORDS

Review training documentation for the following:

(1) Adequacy. Have the DSS handling system operators been properly trained IAW the training documentation?

II. VISUAL INSPECTION OF DSS HANDLING SYSTEM

Perform the following component inspections:

A. Structure (includes handrails, ladders, and walkways; however, the main emphasis is on load bearing structure).

Inspect for:	sat	unsat
(1) Damage, cracking, and corrosion.	____	_____
(2) Loose fasteners.	____	_____
(3) Cracked welds.	____	_____

B. Support Pins, Bushings, and Retainers.

Inspect for:

(1) Proper installation.	____	_____
(2) Wear and distortion.	____	_____
(3) Lubrication.	____	_____

C. Machinery (includes machinery components and foundations).

Inspect for:

(1) Distortion.	____	_____
(2) Cracked welds.	____	_____
(3) Misalignment.	____	_____
(4) Corrosion.	____	_____
(5) Bearing surfaces of fasteners.	____	_____
(6) Missing, incorrect, or defective material fasteners.	____	_____
(7) Alignment, damage, and fastener tightness on any gear covers.	____	_____
(8) Damaged lubrication lines and damaged or missing fittings.	____	_____
(9) Damaged linkage or signs of binding.	____	_____
(10) Loose, damaged, or corroded couplings and signs of binding.	____	_____
(11) Uneven wear of brake linings.	____	_____
Also check for full lining contact, and missing or broken parts.	____	_____
(12) Uneven wear of gear teeth, and adequate lubrication.	____	_____

Figure H-1 (Cont'd)

D. Sheaves and Rollers.

Inspect for:	sat	unsat
(1) Wear and damage.	____	_____
(2) Worn bearings and pins.	____	_____
(3) Damaged or missing lubrication fittings.	____	_____
(4) Wear in rope grooves.	____	_____
(5) Corrosion.	____	_____
(6) Lubrication.	____	_____
(7) Loose or damaged sheave guards.	____	_____

E. Hoist Drums.

Inspect for:

(1) Cracks or distortion.	____	_____
(2) Missing or loose fasteners.	____	_____
(3) Cracked welds.	____	_____
(4) Lubrication.	____	_____

F. Hydraulic Systems (including the HPU).

Inspect for:

(1) Leaking seals.	____	_____
(2) Loose connections.	____	_____
(3) Proper fluid level in the reservoir.	____	_____
(4) Verify that all gages and meters are within calibration date.	____	_____
(5) Inspect all tubing and hoses for correct installation.	____	_____
(6) Cylinders for pitting or faulty seals.	____	_____
(7) Cylinder mountings and pins.	____	_____
(8) Filter indicators.	____	_____
(9) Proper mounting of components.	____	_____

G. Electrical System (including components on HPU).

Inspect for:

(1) Weather damage or moisture.	____	_____
(2) Frayed and cracked insulation.	____	_____
(3) Loose wires and connections.	____	_____
(4) Damaged covers.	____	_____
(5) Verify that all gages and meters are within calibration date.	____	_____
(6) Verify all electric motors are properly lubricated.	____	_____
(7) General condition of motors and motor controllers.	____	_____
(8) Adequacy of normal and emergency lighting.	____	_____

Figure H-1 (Cont'd)

H. Control Console.

Inspect for:	sat	unsat
(1) Deterioration.	____	_____
(2) Corrosion.	____	_____
(3) Loose fasteners and components.	____	_____
(4) Missing label plates.	____	_____
(5) Verify all gages and meters are within calibration date.	____	_____

I. Operator Control Station.

Inspect for:

(1) Leaks.	____	_____
(2) Broken Glass.	____	_____
(3) Corrosion.	____	_____
(4) Proper communications to the bridge and to other cognizant DSS handling system personnel.	____	_____

J. Synthetic lines.

Inspect for:

(1) See Table 2 for criteria.	____	_____
(2) No. of Cycles:_____ (2 yrs or 250 lift cycles).	____	_____

K. Wire Rope.

Inspect for:

(1) Reduction of nominal rope diameter due to loss of core support or internal or external corrosion or wear of individual outside wires.	____	_____
(2) Number of broken outside wires and degree of distribution or concentration of broken wires.	____	_____
(3) Corroded, pitted, or broken wires at end connections.	____	_____
(4) Corroded, cracked, bent, worn, slipped, or improperly applied end connections.	____	_____
(5) Severe kinking, crushing, or distortion of rope structure.	____	_____
(6) Evidence of heat damage from any cause.	____	_____
(7) Verify internal inspections have been conducted in accordance with PMS.	____	_____
(8) No. of Cycles:_____ (2 yrs or 500 lift cycles).	____	_____

(See Table 1 for wire rope replacement criteria)

_____

Auditors signature/Organization/Date

Figure H-1 (Cont'd)

Wire Rope Replacement Criteria:

(1) The nominal diameter of the rope is reduced by more than the amount shown in Table 1 below.
(2) Six broken wires in one rope lay length, or three broken wires in one strand lay length.
(3) One broken wire within one rope lay length of any end fitting.
(4) Wear of 1/3 the original diameter of outside individual wires.
(5) Evidence of pitting due to corrosion.
(6) Evidence of heat damage from any cause.
(7) Kinking, crushing, or any other damage resulting in distortion of the rope structure.
(8) Evidence of internal corrosion, broken wires on the underside of strands, excessive nicks or core failure.
(9) Fatigue Fractures (broken wires in the valleys or on the crowns).

Table 1. Wire Rope Replacement Criteria

Rope Diameter (Inches)	Maximum Allowable Nominal Diameter Reduction (Inches)
5/16 and smaller	1/64
3/8 to 1/2	1/32
9/16 to 3/4	3/64
7/8 to 1-1/8	1/16
1-1/4 to 1-1/2	3/32
1-9/16 to 2	1/8
2-1/8 to 2-1/2	5/32

III. NO-LOAD TEST

Observe the no-load test to evaluate the functional performance of the DSS handling system. The DSS handling system shall be operated through its full range of motions and directions. Check for unusual noise, vibration, or overheating in machinery and control components. Also check for proper operation of all indicator lights and gages.

A no-load test (was/was not) conducted and the DSS handling system is (sat/unsat).

_____
Auditors signature/Organization/Date

IV. FUNCTIONAL TEST OF THE EMERGENCY CONTROLS (If applicable)

Operate the DSS handling system with the emergency controls to evaluate their performance.

Emergency controls were operated and found (sat/unsat)

_____
Auditors signature/Organization/Date

Figure H-1 (Cont'd)

Table 2. Synthetic Line Inspection Criteria

Characteristic	Resplice (if localized)	Discard
1. Rope suspected of being shock loaded		X
2. Rope that has exceeded 75 percent of its minimum breaking strength.		X
3. Bulk of surface yarns or strands reduced by 50 percent or more for a linear distance equal to, or greater than, four times the rope diameter.	X	X
4. Three or more adjacent cut yarns in the strands of ropes to 4-1/2 inch circumference.	X	X
5. Four or more adjacent cut yarns in the strands of ropes 5-inch circumference and over.	X	X
6. Stretchout: Circumference reduced by 5 percent from circumference when new. (Measured under a slight tension $200*D^2$ in pounds.)		X
7. Cockling.	X	X
8. Oil and grease.	Wash in mild detergent	
9. Heavy surface fuzz progressive.	X Remove source of abrasion	X
10. Burns or melting visible for a length of over four times the rope diameters.	X	X
11. Rust on nylon.	X (or clean)	
12. More than four adjacent pulled cover strands (which cannot be reincorporated into cover braid).	X	X
13. Core visible through cover because of cover damage (except single braids).	X	X
14. Core damage -- pulled, cut, abraded, or melted strands.		X
15. Damage to female side of eye.	X	
<u>FOR 3-STRAND AND 8-STRAND PLAITED ROPES</u>: 16. Damage in valley between strands.	X	X
17. Powdering between adjacent strand contact surfaces.	X	X
WHEN IN DOUBT, REMOVE FROM SERVICE!		

Figure H-1 (Cont'd)

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APPENDIX I

RE-ENTRY CONTROL PROCEDURES

I.1 INTRODUCTION

This appendix provides the control processes, procedures and responsibilities to maintain the DSS critical systems in an "as-tested and accepted" condition. REC is the procedure used to provide an identifiable, accountable and auditable record of work performed within the SOC to provide positive assurance that all systems, subsystems and components are maintained in a fully certified condition. The REC processes or a control system and procedures that fulfill the requirements contained herein are mandatory for any activity conducting work within the SOC. A "re-entry" occurs any time that the boundary of a "certified" system is disturbed (e.g., breaking a mechanical flange or a silver brazed or welded joint, removal of a valve bonnet, repairing a gland, repairing or replacing electrical system components, etc.). Re-entry includes any and all work and testing on equipment/systems within the SOC, from first broaching to final testing and return to service. Operation of components or systems within the boundary in accordance with their intended function does not require REC procedures. The objective of REC procedures is to provide a high level of confidence that any work accomplished within the SOC is authorized and executed in accordance with specifications, directives, etc., and is supported by documented evidence which will withstand thorough investigation during the operational life of the vessel. Such evidence will verify:

a. Work was authorized and planned to be accomplished in a deliberate manner.

b. Production work was accomplished in accordance with specified instructions and required documentation has been completed, reviewed and is correct.

c. The documentation and certification for production work have been reviewed for accuracy and completeness by an independent party.

d. The testing documentation has been reviewed for accuracy and completeness.

e. All certifications related to the REC process have been reviewed for correctness and verified to be complete before the re-entry is closed.

Those portions of the REC form, Figure I-1, corresponding to the above actions are identified by the same letters in the left hand margin of the form.

A REC shall identify all requirements for work accomplishment and define the OQE required to support the breach and recertification of the DSS SOC boundary. There will be cases where the REC form does not have sufficient space to provide the

detailed information required. When this occurs, supplemental documents (e.g., detailed work procedures, technical repair standards, etc.) shall be used to meet the requirements of Blocks 10, 11, and 12 of the REC. These supplemental documents shall become part of the re-entry package and shall be maintained with the REC.

Work procedures and other supplemental documents shall provide specific control points within the process where independent inspections must be accomplished (e.g., weld joint fit-up, proper installation of internal valve components, etc.). The REC or its associated supplemental documents shall identify the instructions, or parts thereof, that provide specific guidance to the worker for each step of work to be accomplished.

The work procedure process shall include a revision process to change the work procedures and control the requirements when the scope of work is changed (e.g., adding weld repair where the initial work scope required only inspection). Changes to work procedures shall also require revision of the REC. To support the documentation required by Block 12 of the REC, written work procedures shall be used to accomplish the following:

a. Invoke technical requirements and define specific part of the reference documents required to accomplish the specified work.

b. Define and invoke inspection criteria and inspection record requirements.

c. Identify specific testing and test record requirements.

d. Invoke QA instructions which govern the accumulation of OQE necessary to prove that the material integrity of the DSS has been maintained.

(1) Signatures (who signs and what is being signed for).

(2) Instrumentation/equipment (gages, torque wrenches, etc.) selection (range), calibration, and use.

(3) Qualifications (worker and inspector).

(4) Data sheets to be used and data to be recorded (serial numbers, calibration due dates, pressure, fastener torque, etc.) unless the specific values are listed in a step in the work procedure and signed for as having been accomplished in accordance with the procedure.

I.2 RE-ENTRY CONTROL IMPLEMENTATION RESPONSIBILITIES

Sustaining Activities, Fleet Maintenance Activities, and industrial facilities (e.g., civilian and naval shipyards/contractors) are responsible for implementing and administering REC requirements. The Sustaining Activity is responsible for maintaining

certification and shall invoke a written agreement with each activity performing work within the SOC Boundary.

These agreements shall define the activity's functions and responsibilities for implementing and administering REC procedures and shall be invoked prior to the activity initiating work.

I.3 REC CLOSEOUT

All RECs shall be closed out prior to releasing a DSS for operations. As a general policy, RECs shall not be closed out until all actions necessary to re-establish certification including testing, have been completed. An acceptable alternative, however, is to close out a REC by transferring the remaining open actions to a separate auditable accountability system. In this case, when the activity reports that all RECs have been closed, they shall also report if any RECs were closed by transferring actions and the status of these transferred actions. All RECs closed in this manner shall be annotated by the activity with the reference documents that contain the transferred actions. All transferred actions must be completed prior to the system being released for operations. Documentation of satisfactory resolutions of these transferred actions shall be included and maintained with the original REC.

I.4 RE-ENTRY CONTROL FORM AND INSTRUCTION MATRIX

The standard REC form and instruction matrix, Figure I-1 and Table I-1, or other locally generated forms which have been approved by the SCA, shall be utilized by all activities when REC is required. All activities shall promulgate internal procedures which utilize Figure I-1 and Table I-1. The REC form and instruction matrix, the detailed work procedures used to support each REC, and the REC Log comprise the REC system which is used in conjunction with existing work authorization procedures, e.g., work permits. The REC procedures specified by NAVSEA 0924-062-0010 or CINCLANTFLT/CINPACFLTINST 4790.3 are considered acceptable, provided that the REC is identified as SOC.

I.5 RE-ENTRY CONTROL LOG

Sustaining Activities and industrial facilities shall establish and administer procedures for REC Logs. REC Logs shall contain the following minimum information:

a. Unique sequential REC numbers, including revisions.

b. DSS or hull number (e.g., DSV-1, DSRV).

c. System re-entered.

d. REC final close out date.

e. Remarks, a summary of the work description of the re-entry and any other pertinent information.

f. REC Log consecutive page number.

In cases where the REC Log contains both SUBSAFE and SOC RECs, SOC RECs shall be identified.

I.6 RE-ENTRY CONTROL RECORD RETENTION REQUIREMENTS

Sustaining Activities and industrial facilities are responsible for establishing and administering procedures for retention of re-entry control records. These procedures shall provide for the following minimum requirements:

a. The REC Log, completed RECs, and supporting documentation shall be maintained for the operational life of the DSS.

b. The Sustaining Activity for the DSS shall maintain the REC records specified in paragraph I.6.a in an auditable condition for the period between DSS major availabilities.

I.7 EXCEPTIONS TO RE-ENTRY CONTROL

Exceptions to REC for specified routine operations or maintenance within the SOC may be authorized by the Program Manager with SCA concurrence. Due to the unique nature of DSS assets, REC exceptions are specific to each particular DSS program. These exceptions are intended to apply to selected routine actions which create little risk of violating certification requirements such as material certification, assembly or testing. Such exceptions normally consist of routine PMS or operation of components or systems in accordance with their intended function and approved operating procedures.

When REC is not required, all other documentation normally required by QA/maintenance manuals (e.g., Formal Work Procedures (FWPs), 2-KILOs, QA forms, Specifications, etc.) is still required, and shall be maintained in accordance with the applicable maintenance instruction.

When conducting surveys, documentation for work on those items which are exempted from REC must be reviewed. It may require inspecting the actual equipment, reviewing documentation other than RECs (such as testing, mechanical joint assembly forms, PMS schedules, FWPs or other work packages which do not require RECs, etc.) The CSPs must reflect this requirement.

The following are exceptions to the REC requirements of this manual and include certain systems and equipment within the SOC which require frequent entry into the certified boundary to accomplish routine operations or planned maintenance actions in order to enable the DSS unit to carry out its mission. Specific requests for all REC exceptions for each DSS program must be formally submitted to the Program Manager for review and approval. SCA concurrence is required for all REC exceptions. PMS that is specifically exempted from REC shall be appropriately marked on the MRC. Exceptions shall be listed in the SOC Notebook.

a. Items which are specifically exempted from REC by NAVSEA 0924-062-0010.

b. Form, Fit and Function (FFF) only items for those systems which have FFF only items defined. This does not include joints which connect the FFF item to the Full Compliance (FC) portion of the SOC boundary.

c. When components are operated in accordance with their intended function and operating procedures (e.g., operation of access hatches/doors, installation/removal breathing mask from manifolds, replacement of CO_2 canisters, and replacing LiOH in the scrubbers). (Note 1)

d. Opening of an implodable for the purpose of repairing an electrical or electronic component or changing film. Retain implodable test documentation if a new implodable is installed. (Note 1)

e. PMS inspections that do not require disassembly. (See paragraph 3.9.2 and Note 1)

f. Replacement of externally mounted lights/lamps or navigation/ID beacon. When limited to a mechanical type electrical connector. (Note 1)

g. Post-dive removal of safety batteries and/or portable equipment for routine servicing (Draeger tubes, lift ramps, portable atmosphere monitoring equipment but not atmospheric monitoring circuits except as allowed by the SOC notebook). (Note 1)

h. Repairs to electrical/electronic circuits/components of systems located inside the DSS unit. Limited to radio transceiver and antenna, underwater telephone and transducer, interior communication system, bottom navigation systems, fathometer, SID light, batteries for internal lights, and electrical lighting switchboards. Repairs to safety circuits, jettison or emergency recovery systems emergency lighting circuits, life support monitoring or control circuits, and replacement of wiring are not exempted. (Note 1)

i. Removal/re-installation of certified gas bottles (including rack mounted SCUBA bottles) for charging purposes, when a unit gas log is maintained. (Note 1)

j. Disassembly of electrical/electronic connectors attached to consoles, implodables, or other powered items for the purpose of removing the item or the isolation of ground/resistance faults. Work is authorized provided the cables and connectors themselves are not repaired or disassembled in any manner and after reconnection of the cables, the circuit is checked and documented. (Note 1)

k. Disassembly of mufflers, strainers, handwheels and piping which are vented to atmosphere and downstream of isolation valves. (Note 1)

l. In-place calibration of installed gages using existing calibration test fittings. (Note 1)

m. Removal and installation of implodables. Retain implodable test documentation if a new implodable is installed. (Note 1)

n. Temporary removal of syntactic foam. A log shall be maintained to control the temporary removal of syntactic foam. Prior to submerged operations, the log shall be reviewed by the unit Engineer to ensure that all removed syntactic foam has been properly reinstalled. This log shall be maintained in an auditable manner until the completion of the next SCA audit.

NOTE:

(1) A Formal Work Procedure in accordance with the Force Maintenance Manual (e.g., PMS MRC, technical manual pages, detailed maintenance outline, SCA approved operating or emergency procedure or pre/post dive check list/sheet, etc.) will be used to control and document all work performed as a REC exception.

DEEP SUBMERGENCE SYSTEM RE-ENTRY CONTROL FORM

1. FOR	DESIGNATOR	2. REC NO.	REV.
3. J.O./JCN			
4. ORIGINATOR		5. ORGANIZATION	
6. SYSTEM RE-ENTERED		7. RE-ENTRY LOCATION	
8. COMPONENT(s)			

WORK DESCRIPTION INCLUDING BOUNDARIES

9. SYSTEM/COMPONENT DWG WITH REV

10. WORK TO BE PERFORMED AND WORK REFERENCE DOCUMENTS.

11. APPLICABLE JOINT NO(s), OR IF NOT SUPPLIED, SPECIFIC BOUNDARIES.

VERIFICATION AND CERTIFICATION

12. SUPPORTING DOCUMENTATION

APPROVAL FOR CONTROLLED RE-ENTRY

(A) 13. PRIME APPROVAL SIGNATURE | LEGIBLY PRINTED, TYPED OR STAMPED NAME | DATE

VERIFICATION OF WORK COMPLETION

THE PRODUCTION WORK DESCRIBED BY THIS REC HAS BEEN ACCOMPLISHED IN ACCORDANCE WITH THE SPECIFIED INSTRUCTIONS AND THE REQUIRED DOCUMENTATION LISTED IN BLOCK 12 HAS BEEN COMPLETED, REVIEWED AND IS CORRECT.

(B) 14. APPROVAL SIGNATURE | LEGIBLY PRINTED, TYPED OR STAMPED NAME | DATE

CERTIFICATION OF DOCUMENTATION OF PRODUCTION WORK

ALL DOCUMENTATION AND CERTIFICATION FOR PRODUCTION WORK SPECIFIED IN BLOCK 12 HAVE BEEN COMPLETED. THE DOCUMENTATION HAS BEEN REVIEWED FOR ACCURACY AND COMPLETENESS.

(C) 15. APPROVAL SIGNATURE | LEGIBLY PRINTED, TYPED OR STAMPED NAME | DATE

CERTIFICATION OF TESTING RESULTS

THE TESTING INVOKED FOR THIS REC HAS BEEN COMPLETED. THE TEST DOCUMENTATION SPECIFIED IN BLOCK 12 HAS BEEN REVIEWED FOR ACCURACY AND COMPLETENESS BY THE COGNIZANT TECHNICAL AUTHORITY.

(D) 16. APPROVAL SIGNATURE | LEGIBLY PRINTED, TYPED OR STAMPED NAME | DATE

FINAL REC CLOSEOUT CERTIFICATION

ALL CERTIFICATIONS RELATED TO THIS REC HAVE BEEN REVIEWED FOR CORRECTNESS AND VERIFIED TO BE COMPLETE. I CERTIFY THIS RE-ENTRY IS CLOSED.

(E) 17. PRIME APPROVAL SIGNATURE | LEGIBLY PRINTED, TYPED OR STAMPED NAME | DATE

18. OFFICER IN CHARGE SIGNATURE | LEGIBLY PRINTED, TYPED OR STAMPED NAME | DATE

Figure I-1

TABLE I-1. RE-ENTRY CONTROL FORM INSTRUCTION MATRIX

BLOCK NO.	SYSTEM	SYSTEM & IMA OR IMA ONLY	GOVERNMENT ACTIVITY	PRIVATE ACTIVITY
1	Enter System name and System designator.	Enter System name and System designator.	Enter System name and System designator.	Enter System name and System designator.
2	Obtain the next serial number in sequence from the System's Quality Assurance Representative and enter in space. Revision "-" shall be entered on the initial version of all RECs. When a revision is required, prepare a new REC utilizing the original numbers plus the next revision letter.	Obtain the next serial number in sequence from the System's Quality Assurance Representative (or IMA QAO for IMA only RECs) and enter in space. Revision "-" shall be entered on the initial version of all RECs. When a revision is required, prepare a new REC utilizing the original numbers plus the next revision letter.	Enter the next serial number in sequence in the REC Log. Initial version of the REC shall be Revision "-". When a revision is required, prepare a new REC utilizing the original number plus the next revision letter. The REC Log shall be one sequential list for each System and availability.	Enter the next serial number in sequence in the REC log. When a revision is required, prepare a new REC utilizing the original number plus the next revision letter. The REC Log shall be one sequential list for each System and availability.
3	Enter the Job Control Number (JCN) for the maintenance action.	Enter the Job Control Number (JCN) for the maintenance action.	Enter the Job Order/Key Operation number for the work item.	Enter the appropriate work identifier or control number.
4	Enter the name of the person requesting the REC.	Enter the name of the person requesting the REC.	Enter the name of the person requesting the REC.	Enter the name of the person requesting the REC.
5	Enter the organization identification of the person requesting the REC.	Enter the organization identification of the person requesting the REC.	Enter the organization identification of the person requesting the REC.	Enter the organization identification of the person requesting the REC.
6	Identify the system(s) being re-entered.	Identify the system(s) being re-entered.	Identify the system(s) being re-entered.	Identify the system(s) being re-entered.

TABLE I-1. RE-ENTRY CONTROL FORM INSTRUCTION MATRIX (CONT'D)

BLOCK NO.	SYSTEM	SYSTEM & IMA OR IMA ONLY	GOVERNMENT ACTIVITY	PRIVATE ACTIVITY
7	Identify the physical location, i.e., System or shop.	Identify the physical location, i.e., System or shop.	Identify the physical location, i.e., System or shop.	Identify the physical location, i.e., System or shop.
8	Identify the noun name of the component(s) being re-entered.	Identify the noun name of the component(s) being re-entered.	Identify the noun name of the component(s) being re-entered.	Identify the noun name of the component(s) being re-entered.
9	Enter the number of the revision of the applicable mapping plan (or system diagram if not mapped) which depicts the disturbances (shipboard). For component repairs, enter the applicable document (Standard Navy Valves Dwg., vender dwg., etc.) which depicts the disturbances of the item (work-in-place or shop work). Based on the scope of work planned, several drawings may need to be referenced. If necessary, local sketches are authorized to depict disturbances and describe joints to be broken.	Enter the number of the revision of the applicable mapping plan (or system diagram if not mapped) which depicts the disturbances (shipboard). For component repairs, enter the applicable document (Standard Navy Valves Dwg., vender dwg., etc.) which depicts the disturbances of the item (work-in-place or shop work). Based on the scope of work planned, several drawings may need to be referenced. If necessary, local sketches are authorized to depict disturbances and describe joints to be broken.	Enter the number of the revision of the applicable mapping plan (or system diagram if not mapped) which depicts the disturbances (shipboard). For component repairs, enter the applicable document (Standard Navy Valves Dwg., vender dwg., etc.) which depicts the disturbances of the item (work-in-place or shop work). Based on the scope of work planned, several drawings may need to be referenced. If necessary, local sketches are authorized to depict disturbances and describe joints to be broken.	Enter the number of the revision of the applicable mapping plan (or system diagram if not mapped) which depicts the disturbances (shipboard). For component repairs, enter the applicable document (Standard Navy Valves Dwg., vender dwg., etc.) which depicts the disturbances of the item (work-in-place or shop work). Based on the scope of work planned, several drawings may need to be referenced. If necessary, local sketches are authorized to depict disturbances and describe joints to be broken.

TABLE I-1. RE-ENTRY CONTROL FORM INSTRUCTION MATRIX (CONT'D)

BLOCK NO.	SYSTEM	SYSTEM & IMA OR IMA ONLY	GOVERNMENT ACTIVITY	PRIVATE ACTIVITY
10	The organization identification concerned shall identify the total scope of work and testing required for certification of this re-entry. Enter the work description and make positive reference to the Controlled Work Package which contains the detailed work procedure, material requirements, testing and certification to be performed.	The organization identification concerned shall identify the total scope of work and testing required for certification of this re-entry. Enter the work description and make positive reference to the Controlled Work Package which contains the detailed work procedure, material requirements, testing and certification to be performed.	Enter the total scope of work involved and list the work reference documents which contain the detailed work requirements.	Identify the total scope of work involved. List the reference document(s) which provide or reference work instructions.
11	Identify the joint numbers to be entered. If joint numbers are not supplied, the disturbances shall be uniquely described. This may be done using piece numbers or item description directly relating to the referenced documents, or a locally assigned joint identification.	Identify the joint numbers to be entered. If joint numbers are not supplied, the disturbances shall be uniquely described. This may be done using piece numbers or item description directly relating to the referenced documents, or a locally assigned joint identification.	Identify the joint numbers to be entered. If joint numbers are not supplied, the disturbances shall be uniquely described. This may be done using piece numbers or item description directly relating to the referenced documents, or a locally assigned joint identification.	Identify the joint numbers to be entered. If joint numbers are not supplied, the disturbances shall be uniquely described. This may be done using piece numbers or item description directly relating to the referenced documents, or a locally assigned joint identification.

TABLE I-1. RE-ENTRY CONTROL FORM INSTRUCTION MATRIX (CONT'D)

BLOCK NO.	SYSTEM	SYSTEM & IMA OR IMA ONLY	GOVERNMENT ACTIVITY	PRIVATE ACTIVITY
12	The responsible person concerned shall identify all supporting documentation and data required (QA Form 17, QA Form 17A, QA Form 34(3), NDT records, etc.) as established by the Controlled Work Package. (See NOTE 1)	The Lead Work Center's responsible person shall identify all supporting documentation and data required (QA Form 17, QA Form 17A, QA Form 34(3), NDT records, etc.) as established by the Controlled Work Package. (See NOTE 1)	Identify all supporting documentation and data required for re-entry certification as established and certified by the Cognizant Technical Authority, i.e., Design Division Office. (See NOTE 1)	Identify all supporting documentation and data required for re-entry certification as established and certified by the Cognizant Technical Authority. (See NOTE 1)
13	The Engineer shall sign and date, and legibly print, type or stamp his name, granting permission for work to commence. No re-entry work can start prior to this signature. This signature establishes the re-entry start date and signifies that formal certification of system/ component must occur. (See NOTE 2)	The Engineer or Repair Officer, as appropriate, shall sign and date, and legibly print, type or stamp his name, granting permission for work to commence. No re-entry work can start prior to this signature. This signature establishes the re-entry start date and signifies that formal certification of system/component must occur. (See NOTE 2)	Repair Activity representative shall sign and date, and legibly print, type or stamp his/her name, verifying that the information in Blocks 1-12 accurately identifies the work to be performed and the boundaries to be re-entered. No re-entry work can start prior to the signature. (See NOTE 2)	A designated member from the organization responsible for controlling REC shall sign and date, and legibly print, type or stamp his/her name after reviewing Blocks 1-12 for accuracy and completeness. (See NOTE 2)

TABLE I-1. RE-ENTRY CONTROL FORM INSTRUCTION MATRIX (CONT'D)

BLOCK NO.	SYSTEM	SYSTEM & IMA OR IMA ONLY	GOVERNMENT ACTIVITY	PRIVATE ACTIVITY
14	The organization identification concerned shall sign and date, and legibly print, type or stamp his name, verifying the production work described by the REC has been accomplished in accordance with the specified instructions and that the required documentation as listed in Block 12 has been completed, reviewed and is correct.	The Lead Work Center's organization identification shall sign and date, and legibly print, type or stamp his/her name, verifying the production work described by the REC has been accomplished in accordance with the specified instructions and that the required documentation as listed in Block 12 has been completed, reviewed and is correct.	Production shop supervisor responsible for work accomplishment shall sign and date, and legibly print, type or stamp his/her name after verification of production work and documentation completion.	The supervisor responsible for work accomplishment shall sign and date, and legibly print, type or stamp his/her name after verification of production work and documentation completion.
15	The System's Quality Assurance Representative concerned shall sign and date, and legibly print, type or stamp his name, signifying that all documentation and certification for production work specified in Block 12 have been completed and the documentation has been reviewed for accuracy and completeness.	The IMA Quality Assurance Representative shall sign and date, and legibly print, type or stamp his/her name, signifying that all documentation and certification for production work specified in Block 12 have been completed and the documentation has been reviewed for accuracy and completeness.	The Inspection Supervisor or designated representative shall sign and date, and legibly print, type or stamp his/her name after all documentation has been reviewed for accuracy and completeness.	The appropriate representative shall sign and date, and legibly print, type or stamp his/her name after reviewing the REC form and supporting re-entry certification documentation for accuracy and completeness.

TABLE I-1. RE-ENTRY CONTROL FORM INSTRUCTION MATRIX (CONT'D)

BLOCK NO.	SYSTEM	SYSTEM & IMA OR IMA ONLY	GOVERNMENT ACTIVITY	PRIVATE ACTIVITY
16	The System's Quality Assurance Representative shall sign and date, and legibly print, type or stamp his name, signifying that the testing invoked for this REC has been completed and the test documentation specified in Block 12 has been reviewed for accuracy and completeness by the Cognizant Technical Authority. (See NOTE 1)	The IMA Quality Assurance Representative shall sign and date, and legibly print, type or stamp his/her name, signifying that the testing invoked for this REC has been completed and the test documentation specified in Block 12 has been reviewed for accuracy and completeness by the Cognizant Technical Authority. (See NOTE 1)	A repair activity representative shall sign and date, and legibly print, type or stamp his/her name after completion of testing and test results have been approved by the Cognizant Technical Authority. (See NOTE 1)	The Cognizant Technical Authority responsible for reviewing REC for proper testing requirements shall sign and date, and legibly print, type or stamp his/her name after ensuring that testing is adequate for certification and has been completed. (See NOTE 1)
17	The Engineer shall sign and date, and legibly print, type or stamp his name, verifying that all certifications related to this REC have been reviewed for correctness and are complete. (See NOTE 1)	The Repair Officer shall sign and date, and legibly print, type or stamp his/her name, verifying that all certifications related to this REC have been reviewed for correctness and verified complete. (See NOTE 1)	Inspector Supervisor or designated representative, who is completely accountable and responsible, shall sign and date, and legibly print, type or stamp his/her name after reviewing the completed documentation package. This individual shall not have signed Block 15. (See NOTE 1)	A designated member from the organization responsible for controlling the REC shall sign and date, and legibly print, type or stamp his/her name after reviewing the REC form and supporting re-entry certification document. (See NOTE 1)

TABLE I-1. RE-ENTRY CONTROL FORM INSTRUCTION MATRIX (CONT'D)

BLOCK NO.	SYSTEM	SYSTEM & IMA OR IMA ONLY	GOVERNMENT ACTIVITY	PRIVATE ACTIVITY
18	The Officer In Charge shall sign and date, and legibly print, type or stamp his name, acknowledging that the REC has been closed by the Engineer.	For "System & IMA" RECs, the Officer In Charge shall sign and date, and legibly print type or stamp his name, acknowledging that the REC has been closed by the Repair Officer. For "IMA only" RECs, this block is left blank.	This block is left blank.	This block is left blank.

NOTE 1: When an activity closes out a REC by transferring the remaining open actions to a separate auditable accountability system, Block 12 shall be revised to identify the reference documents that contain the transferred actions. The Block 16 signature then signifies that the reference documents have been reviewed, contain the transferred actions, and that the actions required by the reference documents will fulfill the recertification requirements. The Block 17 signature verifies that the documentation package for closing the REC has been reviewed and is complete.

NOTE 2: Where authorized by local procedures, the sequencing of Blocks 12 and 13 is optional.

APPENDIX J

DSS PIPE AND PIPING COMPONENTS PRESSURE TESTING REQUIREMENTS

J.1 INTRODUCTION

This appendix provides direction pertaining to the minimum mandatory testing requirements for DSS pipe and piping components. Requirements are provided for hydrostatic testing, joint tightness testing, seat tightness testing, pressure drop testing, and the OQE necessary to document the accomplishment of the pressure testing. Where the requirements of this appendix conflict with existing directives, specifications or requirements, the conflict will be documented and addressed to the SCA for resolution.

J.2 RESTRICTIONS

Requirements contained herein do not apply to hydraulic systems, tanks, or items classified as explodable or implodable in accordance with this manual.

J.3 DEFINITIONS

a. Design Test Depth Pressure: The pressure equivalent to the maximum depth to which the DSS was designed to operate.

b. Hydrostatic (Strength & Porosity) Test: A test which subjects pressure-containing structural boundaries of pipe and piping components to either 135 percent of system design pressure or 150 percent of maximum operating pressure.

c. Isolation Valve: Any valve used as a distinct pressure boundary which in the no-flow position (closed) does not incorporate a self-operating feature (i.e., check valves and regulating valves).

d. Joint Tightness Test: A test which subjects mechanically joined pressure-containing boundaries of pipe and piping components to an internal pressure equal to 100 percent of maximum operating pressure, and if applicable, an external pressure equal to 100 percent of DSS design test depth pressure.

e. Major Repair: Any work/rework where the pressure-containing boundary of pipe or piping components is affected by welding, brazing or other fabrication processes which could affect the structural adequacy of the material or component.

NOTE: Component renewal (including pressure boundary piece parts and/or assemblies) is a major repair unless the component has been hydrostatically tested prior to installation into the assembly or system. Replacement of the

following items is not considered a major repair: valve packing, pump packing, pump mechanical shaft seals, seals (gaskets and o-rings), mechanical joint bolting (bolts, studs, washers, locking devices and nuts), and valve stems.

f. Maximum Operating Pressure: The highest pressure that can exist in a system or subsystem under normal (non-casualty) operating conditions. This pressure is determined by such influences as pressure-regulating valve set pressure, maximum pressure at the system source such as compressed gas bank pressure or sea pressure, and pump shut-off pressure for closed systems.

NOTE: For systems with pressure-regulating valves where the downstream piping does not incorporate a relief valve, the maximum operating pressure of the upstream side of the pressure-regulating valve shall be the maximum operating pressure of the downstream side of the pressure-regulating valve for test purposes. For constant pressure systems, such as regulated compressed gas systems, the term Nominal Operating Pressure has been used to designate the steady state operating condition. Where this type of pressure rating is applied, for the purpose of the requirements stated herein, it may be substituted as the maximum operating pressure.

g. Minor Repair: Any repair/rework where the pressure-containing boundary of pipe or piping components is not affected by welding, brazing or other fabrication processes which could affect the structural adequacy of the material or component.

NOTE: Reassembled mechanical joints, replacement of gaskets and seals, weld repairs of the surface seating area of mechanical joint flanges, and epoxy repairs in accordance with approved procedures are all considered minor repairs.

h. Pressure Drop Test: A test which identifies long term leakage of a system. Compressed gas flasks, pipe and piping components are initially pressurized to 100 percent of maximum operating pressure. Data are then taken to measure the change in pressure, corrected for temperature, over an extended period of time.

i. Seat Tightness Test: An internal pressure test that checks a valve's shut-off/isolation capabilities.

j. System Design Pressure: The pressure used in calculating minimum wall thicknesses of piping and piping components. The system design pressure shall be not less than the nominal setting of the component relief valves.

J.4 TEST PRESSURE TOLERANCES

The pressure used to perform a hydrostatic test, joint tightness test, seat tightness test or pressure drop test shall be in accordance with Naval Ship's Technical Manual NAVSEA S9086-RK-STM-010/CH-505, Piping Systems, unless otherwise specified.

J.5 TEST PRESSURE DURATION

a. The duration of pressure testing of piping and components, including pressure-containing piece parts, conducted in a shop or on a test bench shall be as specified in the appropriate military specification/standard, manufacture drawing, or component technical manual. In the absence of direction, the test duration shall not be less than 1 minute soak time plus sufficient time for inspection.

b. The duration of pressure testing of piping and components, including pressure-containing piece parts, conducted in the installed DSS configuration shall be as specified in the applicable military specification/standard, approved system drawing, or Naval Ship's Technical Manual. In the absence of direction, the test duration shall not be less than 15 minutes soak time plus sufficient time for inspection.

J.6 HYDROSTATIC TESTING REQUIREMENTS

a. Hydrostatic testing, including acceptance criteria, of DSS piping and piping components shall be as specified in Naval Ship's Technical Manual S9086-RK-STM-010/CH-505, Piping Systems, MIL-STD-1330, Precision Cleaning and Testing of Shipboard Oxygen, Helium, Helium-Oxygen, Nitrogen, and Hydrogen Systems, and as specified herein when applicable.

b. Pipe and piping components whose pressure boundary is externally loaded by sea pressure, but whose internal maximum operating pressure is equal to or greater than DSS design test depth pressure, shall only require an internal hydrostatic test.

c. Pipe and piping components whose pressure boundary is externally loaded by sea pressure, but whose internal maximum operating pressure is less than DSS design test depth, shall only require an external hydrostatic test. (See Paragraph J.6.g)

NOTE: In the event that a required external hydrostatic test is unable to be conducted due to equipment availability, test component configuration, etc., an internal hydrostatic test at a pressure equal to 150 percent of DSS design test depth may be substituted. NAVSEA approval shall be obtained prior to substituting an internal hydrostatic test for any required external hydrostatic test. Approval will be dependent on documentation that demonstrates the ability of the pipe and/or piping component(s) to withstand the required internal pressure.

d. Pipe and piping components that penetrate any hull integrity boundary (tanks, spheres, skirts, etc.) where a single failure could result in internal flooding of the DSS shall be hydrostatically tested from the hull integrity boundary penetration inboard to the first isolation valve at a pressure equal to 150 percent of DSS design test depth pressure or 150 percent of system maximum operating pressure, whichever is greater.

e. Pipe and piping components open to internally pressurized tanks and/or enclosures (including hyperbaric chambers) shall be hydrostatically tested internally from the tank and/or enclosure penetration outboard to the first isolation valve at a pressure equal to the pressure used to hydrostatically test the tank and/or enclosure.

NOTE: The requirements of paragraph J.6.e are not applicable to piping and piping components open to compressed gas flasks.

f. Leakage past mechanical joints or valve seats during hydrostatic testing shall not be cause for rejection.

NOTE: Incompressible fluid system mechanical joints which experience zero leakage during a hydrostatic test do not require joint tightness testing in the direction applied by the hydrostatic test. Compressed gas system mechanical joints which experience zero leakage during a hydrostatic test still require joint tightness testing because of the physical difference in test fluids (liquid versus gas).

g. External hydrostatic test acceptance criteria of "no permanent deformation" for pipe shall, in addition to a complete visual inspection, be verified by out-of-roundness measurements (defined as the difference between the major and minor outside dimensions at any one cross-section). Out-of-roundness measurements not within the pipe specification, approved drawing or MIL-STD-1627 (for pipe bends) shall be cause for rejection of the item.

NOTE: Measurements for out-of-roundness shall be taken as close as possible to the center of the unsupported axial length. As an example, given a pipe assembly with 6 feet of pipe between two flanges or unions, the point of measurement would be at the midpoint of the 6 foot pipe length. Out-of-roundness measurements shall not be taken for pipe fittings.

J.7 JOINT TIGHTNESS TESTING REQUIREMENTS

a. New, major or minor repaired pipe and piping components shall be subjected to an internal joint tightness test prior to system operational testing or use. Joint tightness testing of oxygen, helium, helium-oxygen, nitrogen, and hydrogen systems shall be as specified in MIL-STD-1330, and as specified herein when applicable.

b. Pipe and piping components whose pressure boundary is externally loaded by sea pressure, but whose internal maximum operating pressure is equal to or greater than DSS design test depth pressure, shall only require an internal joint tightness test.

c. Pipe and piping components whose pressure boundary is externally loaded by sea pressure, but whose internal maximum operating pressure is less than DSS design test depth pressure shall require both external joint tightness testing and internal joint tightness testing.

NOTE: The ability to conduct external joint tightness testing is extremely limited. Recognizing the limitations, accomplishment of this testing is normally deferred by assembling the affected joints using "controlled assembly" procedures, similar to those specified by Forces Afloat Quality Assurance Manuals, and completing a controlled dive to design test depth which results in no leakage.

d. Pipe and piping components open to internally pressurized tanks and/or structural enclosures (including hyperbaric chambers) shall be joint tightness tested internally from the tank and/or enclosure penetration outboard to the first isolation valve at a pressure equal to 100 percent of the maximum internal operating pressure of the tank and/or enclosure.

NOTE: The requirements of paragraph J.7.d are not applicable to piping and piping components open to compressed gas flasks.

e. Pipe and piping components that penetrate any hull integrity boundary (tanks, spheres, skirts, etc.) where a single failure could result in internal flooding of the DSS shall be joint tightness tested from the hull integrity boundary penetration inboard to the first isolation valve at a pressure equal to 100 percent of DSS design test depth pressure or 100 percent of system maximum operating pressure, whichever is greater.

f. Acceptance criteria for joint tightness testing shall be zero leakage, unless otherwise specified.

J.8 SEAT TIGHTNESS TESTING REQUIREMENTS

a. New, disassembled or refurbished valves shall be subjected to a seat tightness test prior to system operational use. Seat tightness testing of oxygen, helium, helium-oxygen, nitrogen and hydrogen systems shall be as specified in MIL-STD-1330, and as specified herein when applicable.

b. Globe-type valve designs and poppet valves shall be tested in the direction that tends to unseat the valve. Globe-type designs and poppet valves shall also be tested in the direction that tends to seat the valve when the valve acts as a boundary closure between two distinct operating pressure systems/subsystems.

NOTE: Valves which act as a boundary closure between two distinct operating pressure systems or subsystems shall have the test pressure of each port identified by a temporary tag when testing is performed in a shop or on a test bench and the ports are not otherwise marked or identified. The temporary tags can be removed after the valves have been installed. The purpose of the tagging is to alert personnel to the correct orientation of the valve in the system.

c. Ball valves shall be tested in the direction of flow as determined by the orientation of the valve in the DSS. Ball valves which act as a boundary closure between two distinct operating pressure systems or subsystems shall be tested from both directions. Ball valves which are designated flood control closures shall, in addition to being tested at the maximum system operating pressure, be tested from the direction of the flooding source at a pressure of 100 psig.

NOTE: The test pressure applied to each port shall be identified by temporary tags when testing is performed in a shop or on a test bench and the ports are not otherwise marked or identified. The temporary tags can be removed after a valve has been installed. The purpose of the tagging is to alert personnel to the correct orientation of the valve in the system.

d. Acceptance criteria for seat tightness testing shall be in accordance with applicable military or manufacturer's specifications, approved test documents or as directed by NAVSEA.

J.9 PRESSURE DROP TESTING REQUIREMENTS

a. Pressure drop testing of oxygen, helium, helium-oxygen, nitrogen, and hydrogen systems shall be as specified in MIL-STD-1330.

b. Pressure drop testing of compressed air systems shall be as specified Naval Ship's Technical Manual S9086-SY-STM-010/CH-551, Compressed Air Plants and Systems.

J.10 OBJECTIVE QUALITY EVIDENCE

For DSSs that are subject to certification in accordance with this manual, OQE documenting the satisfactory accomplishment of ALL required testing shall be available and maintained in a format suitable for review and audit. The term "Objective Quality Evidence" is defined in Section 1.3.6. The documentation shall note acceptability by the initials and date of a person either witnessing or performing the test and shall become a part of the completed test procedure. For testing that incorporates individual or multiple test results, an officially designated individual shall sign at the completion of all testing indicating acceptance of all recorded data and certifying the satisfactory

completion of the required test. The format is at the discretion of the user unless otherwise specified. The following information, as a minimum, shall be recorded:

a. Platform and System Tested
b. Date Test Conducted
c. Test Boundary
d. Calibration Dates & Serial Numbers of Test Equipment
e. Test Fittings, Blanks and Jumpers (if applicable)
f. Required Test Pressure
g. Actual Test Pressure
h. Required Test Fluid
i. Required Duration
j. Allowable Leakage
k. Measured Leakage
l. Results of Inspections/Out-of-Roundness Measurements
m. Temperature and Pressure Data Supporting Drop Tests
n. Valve Line-up for Test.

NOTE: Valve line-ups for pressure testing shall provide the following information: valve designator and/or valve nomenclature; required valve positions; initials and date of the Valve Positioner verifying by observation the actual valve positions; and test entry point when an external pressure source is used for an internal pressure test.

o. Test Acceptance Signature

NOTE: The Test Accepted Signature shall be annotated as attesting that the person who actually performed or witnessed the test is verifying that all associated test parameters were met.

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APPENDIX K

CERTIFICATION SURVEY PLAN

K.1 INTRODUCTION

NAVSEA conducts initial certification surveys on each new DSS prior to acceptance by the Navy and prior to completion of an overhaul or other major availability to ensure that the procedures and criteria for attaining/sustaining certification have been satisfied. The surveys sample all work performed and provide a basis for NAVSEA recommendations that the system is satisfactory for conducting manned testing and subsequent issuance of the SCA Letter of Certification.

The CSP supports the certification process by providing all principal participants a document defining the parameters of the NAVSEA certification survey. The plan is a composite list to ensure that each DSS is in compliance with the certification requirements of the applicable specifications and defines the OQE and documentation required to support the survey. The CSP specifies those documents required to be produced in a form suitable for survey to support the certification process.

NOTE: The CSPs provided in this appendix are samples to demonstrate those systems and items to be surveyed for representative systems, in this case a DSV and a DSS handling system. It should be recognized that these are samples to reflect those specifications, respective requirements, and OQE for the representative system and are to be used as guidelines for Program Managers. It should be noted that the example CSP for the DSV in this appendix is for a survey subsequent to the initial certification survey. The CSP for the handling system is for an initial certification survey prior to filling in all "Documentation to Substantiate Requirements" columns and the completion of the CSP.

K.2 CERTIFICATION SURVEY PLAN DEVELOPMENT

The baseline CSP provides the items to be surveyed, description of requirements, and the documentation required to be surveyed by the Program Manager/Sustaining Activity and verified by the SCA prior to issuance of the Letter of Certification. The Program Manager, or his designated representative, is responsible for ensuring certification is maintained for those areas worked during the availability. Where no work is accomplished, certification documentation is not required.

The development of the CSP is a phased process starting with the application for initial certification and continues throughout the life of the DSS. The plan will define the survey requirements for all SOC designated systems, subsystems and components as defined in the DSS SOC.

K.2.1 Proposed Certification Survey Plan

The proposed CSP submitted by the Program Manager with the initial certification application will reflect the survey requirements of this manual as applied to the systems, subsystem and components depicted in the proposed SOC. The Program Manager will evaluate the items to be surveyed and requirements for the DSS to ensure the CSP identifies all documentation to meet the requirements of this manual and support survey verification. Once the proposed CSP is approved by the SCA, it will become the baseline CSP for the life cycle of the DSS.

K.2.2 Certification Survey Plan Review

The Program Manager will arrange for a review and evaluation of the CSP by the Cognizant Technical Authority. The SCA will provide an independent overview of the initial CSP development and technical review to ensure the certification requirements will produce the documentation and OQE required to support the certification survey. After initial certification, all subsequent CSPs will be updated and revised by the Sustaining Activity and the Program Manager. All changes to the CSP other than changes to the documentation to substantiate requirements require SCA approval. Each activity will update the CSP for all items for which it is responsible.

K.3 CERTIFICATION SURVEY PLAN FORMAT AND CONTENT

It is intended that all CSPs contain, as a minimum, the contents of the sample plan. Deviations from the content as defined below will be identified and resolved during the technical certification requirements review and approval. The plan is divided into four parts; Part I - Structural Integrity, Part II - Piping Systems and Components, Part III - Electrical and Communications, Part IV - Completion and Readiness. When complete, the matrices of Parts I, II and III will provide a listing of each item to be surveyed and accountability to each respective system. Part IV, Completion and Readiness, addresses processes and procedures that are applicable to all systems.

K.3.1 Item/System Accountability

This matrix provides a checklist to identify applicability and accountability for each item to be surveyed.

a. System Header: The Program Manager will tailor the baseline CSP to the DSS by completing the vertical column header designation of specific items, components, systems and subsystems that must be addressed during the survey. The sample plans reflect the configuration and systems for a DSV and for a DSS handling system.

b. Item to be Surveyed: The preparing activity identifies and lists each line item (item to be certified) from Parts I, II and III of the CSP.

c. Applicability: The initial certification survey will address and sample as necessary the documentation required and documentation to substantiate requirements for all systems and items to be surveyed. For all subsequent surveys the Program Manager or Sustaining Activity will designate with an X those items to be surveyed for each system that are applicable to the areas in which work was accomplished, during the availability and for which survey is being requested. Where no work is accomplished, documentation is not required and will be indicated with a not applicable (NA).

d. Remarks: This column is provided for notation of any amplifying information during the CSP preparation or by the Surveyor during the survey.

K.3.2 Certification Survey Plan (Parts I, II, III & IV)

The information in the first, third and fourth columns of the sample plan is applicable to all DSSs and will be defined and agreed to during application for initial certification and approval of certification preliminary documents.

a. Item to be Surveyed: Requirement or item that must be surveyed during the performance of the survey.

b. Specification: Identifies the source of the requirement for documentation. In the case of new construction or initial certification this should be the applicable section of the building specification or the specific sub-tier document that provides the documentation requirement.

c. Description of Requirements: This column identifies specific minimum requirements normally prescribed for the certification of the item in column one. In the case of NDT, there are certain instances where the specification permits substituting one test for another.

d. Documentation Required: This column defines OQE to prove satisfactory completion of the work specified by the attributes under "Description of Requirements" to meet the requirements of the specifications.

e. Documentation to Substantiate Requirements: This column will be filled out to identify the specific documents that provide the OQE to prove the survey requirement has been satisfied in a manner to support survey and certification. In the case of initial certification the information will be provided by the industrial facility or as designated by the Program Manager. The Sustaining Activity, industrial facility or Program Manager as appropriate will complete this column for surveys following the initial certification survey.

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NAVAL SEA SYSTEMS COMMAND

CERTIFICATION SURVEY PLAN
FOR
DEEP SUBMERGENCE SYSTEM

SUBMITTAL:

_____ _____
BUILDER/SUSTAINING ACTIVITY DATE

_____ _____
PROGRAM MANAGER DATE

APPROVAL:

_____ _____
NAVSEA SCA DATE

DEPARTMENT OF THE NAVY
2531 JEFFERSON DAVIS HIGHWAY
ARLINGTON, VA 22242-5160

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CERTIFICATION SURVEY PLAN

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GENERAL NOTES

1. The minimum requirements contained in this survey plan in no way relieve the Program Manager, Supervising Authority/Contractor or Sustaining Activity of the responsibility for meeting the requirements of other specifications invoked by contract or other quality assurance requirements. The Program Manager shall establish and maintain an accountability system to ensure that all records required are readily available in an auditable form to support NAVSEA survey.

   Once these actions have been completed and no later than one week prior to the start of the Program Manager-initiated internal Certification Survey, the Program Manager will submit the annotated copy of the Certification Survey Plan (CSP) to the SCA for review and approval.

2. Design parameters, calculations and analysis that have been previously satisfied need not be addressed during the survey. For alterations, modifications or other material changes, Objective Quality Evidence (OQE) will be provided to verify that these items comply with the initial system certification application requirements of this manual and have received the correct technical review and approval by NAVSEA.

3. The Deep Submergence System Scope of Certification (SOC) Notebook defines and details those components, systems and subsystems that are within the SOC and must meet the CSP requirements.

4. Configuration Changes. Only configuration changes within the SOC will be covered by Parts I, II, and III in Sections A, B, C, D, and E of the CSP. All maintenance, repair and replacement work will be covered by Parts I, II, III, in Sections F and IV of the CSP.

5. Maintenance/Repair Items Requiring Re-Entry Control. Maintenance and repair items requiring Re-Entry Control (REC) are addressed in the last sections of Parts I, II and III. Maintenance items that do not require RECs are covered in Part IV of this survey plan.

6. RECs For Related Maintenance/Repairs. RECs for “Related Maintenance” and “Repairs” accomplished since the last survey are identified for each system within the SOC. As a minimum, the auditor shall take the following action:

   Related Maintenance RECs. The auditor will review the REC and associated job package for the maintenance and verify that all required maintenance action within the SOC has been satisfactorily accomplished and is properly documented.

   Repair RECs. The auditor will review the REC and associated job package (if applicable) and ensure OQE is available to show compliance with each “applicable” line item attribute of the CSP. Application of the CSP line item attribute must be determined by the auditor based on actual work accomplished. For example, if pipe/tubing welding within the SOC was accomplished the review would include the attributes from the “Fabrication and Process Control” section (e.g., Joint Fit-up and Preparation, Piping and Component Welding, etc.), the “Material Control” section, the “Qualification” section (e.g., Weld and NDT Personnel and Procedures Qualification, etc.).

ITEM/SURVEY ACCOUNTABILITY

STRUCTURAL INTEGRITY (PRESSURE HULL, HARD STRUCTURE & APPURTENANCES) - I

	ITEMS TO BE SURVEYED	PERSONNEL SPHERE	VARIABLE BALLAST SPHERES	HP AIR SPHERE (MBT)	VIEWPORTS	INSERTS & PENETRATORS	HATCH	MAIN SUPPORT STRUCTURE	SINGLE POINT LIFT, FOUNDATIONS, HANDLING STRUCTURE	ELECTRICAL HULL FITTINGS	BUOYANCY MATL & ATTACHMENT DEVICES		REMARKS
A	DESIGN AND CONFIGURATION MANAGEMENT												
	1. DRAWING AND DESIGN DOCUMENTATION	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	2. SAFETY ANALYSIS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	3. VERIFICATION OF AS-BUILT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	4. TEST PROCEDURES AND DOCUMENTATION	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
B	MATERIAL CONTROL												
	1. MATERIAL PROPERTIES	X	NA	X	NA	NA	NA	X	NA	NA	X		
	2. MATERIAL IDENTIFICATION	X	NA	X	NA	NA	NA	NA	NA	NA	NA		
	3. TRACEABILITY	X	NA	X	NA	NA	NA	X	NA	NA	X		
C	FABRICATION AND PROCESS CONTROL												
	1. JOINT FIT-UP AND PREPARATION	NA	NA	NA	NA	NA	NA	X	NA	NA	NA		
	2. DIMENSION CONTROL	NA	NA	NA	NA	NA	NA	NA	NA	NA	X		
	3. STRUCTURAL WELDS	NA	NA	NA	NA	NA	NA	X	NA	NA	NA		
	4. MATERIAL FORMING	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	5. HEAT TREATMENT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
D	QUALIFICATIONS												
	1. PERSONNEL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	2. EQUIPMENT	NA	NA	NA	NA	NA	NA	NA	NA	X	NA		
	3. PROCEDURES	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
E	TEST PERFORMANCE AND INSPECTIONS												
	1. INTEGRITY TESTING AND INSPECTIONS	NA	NA	NA	NA	NA	NA	NA	NA	X	NA		
	2. LOAD TEST	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		

ITEM/SURVEY ACCOUNTABILITY

STRUCTURAL INTEGRITY (PRESSURE HULL, HARD STRUCTURE & APPURTENANCES) - I

ITEMS TO BE SURVEYED	PERSONNEL SPHERE	VARIABLE BALLAST SPHERES	HP AIR SPHERE (MBT)	VIEWPORTS	INSERTS & PENETRATORS	HATCH	MAIN SUPPORT STRUCTURE	SINGLE POINT LIFT, FOUNDATIONS, HANDLING STRUCTURE	ELECTRICAL HULL FITTINGS	BUOYANCY MATL & ATTACHMENT DEVICES		REMARKS
LISTED BELOW ARE RECs OPENED SINCE LAST SURVEY												
F RELATED MAINTENANCE AND REPAIRS	X	NA	X	NA	NA	NA	X	X	X	X		RECs 017-93 thru 036-93, 038-93, 039-93, 052-93 thru 054-93, 060-93, 063-93, 069-93
	063-93		038-93				039-93	069-93	017-93	060-93		
									018-93			
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									052-93			
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PART I - STRUCTURAL INTEGRITY (PRESSURE HULL, HARD STRUCTURE & APPURTENANCES)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
A. DESIGN AND CONFIGURATION MANAGEMENT				
1. Drawing and Design Documentation	NAVSEA SS800-AG-MAN-010/P9290	Drawing and Design Documentation Development and Review	OQE to document that the SOC has been identified and that the initial SOC design including all changes (alterations, modifications, field changes etc.) affecting the form, fit or function of the SOC have been approved by NAVSEA. Calculations to show collapse pressure, stress levels and minimum thickness. The OQE will document the SOC design development and approval showing that design requirements were defined and that NAVSEA approval of the design, including reviews of design, material used, calculations, analysis, test reports, safety reviews, etc. Confirmation that the approved design and changes have been incorporated into system drawings and documentation (i.e., Drawings, TABs, Valve Manuals, SIBs, SOC Notebook, etc.). Drawing indexes are up to date. Verification that the drawing index correctly identifies the SOC Top Level drawings and diagrams and the lower tier drawings correctly invoke SOC requirements. The lower tier drawing review will verify that SOC and certification requirements contained in the Top Level drawings and diagrams have not been expanded or new requirements initiated in these drawings.	NA
2. Safety Analysis (FEMA)	NAVSEA SS800-AG-MAN-010/P9290	Safety Analysis (Fault Hazard, Fault Tree, System Hazard Analysis, etc.) to show effect of change on personnel safety	OQE to verify a Safety Analysis has been prepared to include changes, additions or deletions to systems and has appropriate approval.	NA
3. Verification of As-built	NAVSEA SS800-AG-MAN-010/P9290	Visual Inspection System	System installed in accordance with approved drawings. Documentation which supports compliance with drawings including latest applicable revision to which verification was accomplished.	NA
4. Test Procedures and Documentation	NAVSEA SS800-AG-MAN-010/P9290	Test Procedures and Revision Review	OQE to verify SOC test procedures have been identified, reflect the approved design, and have been approved by NAVSEA.	NA

PART I - STRUCTURAL INTEGRITY (PRESSURE HULL, HARD STRUCTURE & APPURTENANCES)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
B. MATERIAL CONTROL				
1. Material Properties	NAVSEA SS800-AG-MAN-010/P9290 Syntactic Foam: NAVSEA DWGs (identified by number) Viewports: ASME PVHO-1 EHFs: MIL-C-24217 VB/HP Spheres: NAVSEA DWGs NAVSEA S9074-AB-MMO-010 Personnel Sphere & Support Structure: NAVSEA DWGs	Verification of Material (VM)	OQE to verify that material installed meets specification/drawing requirements (e.g., correct material type, acceptable chemical and mechanical test results, unique test requirements, etc.). COC only required for DGO connectors and penetrators.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
2. Material Identification	NAVSEA SS800-AG-MAN-010/P9290	Material Marking	Appropriate unique markings that identify the material to the applicable test reports.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
3. Traceability	NAVSEA SS800-AG-MAN-010/P9290	Material Traceability Records	Fabrication records documenting unique material identification control numbers which provide traceability to receipt inspection data for material installed.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
C. FABRICATION AND PROCESS CONTROL				
1. Joint Fit-up and Preparation	NAVSEA DWGs (identified by number) NAVSEA S9074-AB-MMO-010 Viewports: ASME PVHO-1	Visual Inspection (VT)	OQE of acceptable clearances, alignment, material, joint type, preparation and cleanliness as required by specification.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)

PART I - STRUCTURAL INTEGRITY (PRESSURE HULL, HARD STRUCTURE & APPURTENANCES)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
2. Dimensional Control	NAVSEA DWGs (identified by number) NAVSEA S9074-AB-MMO-010 Viewports: ASME PVHO-1	Visual Inspection (VT)	OQE of acceptable dimensional inspection results (e.g., circularity checks, sphericity, diameter, depth, fit-up, etc.).	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
3. Structural Welds (Full and Partial Penetration Welds)	NAVSEA DWGs (identified by number) NAVSHIPS 0900-000-1000, NAVSEA S9074-AB-MMO-010, NAVSEA T9074-AS-GIB-010/271	a. Visual Inspection (VT)	OQE as required by specification.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
		b. Magnetic Particle Inspection (MT)	OQE as required by specification.	NA
		c. Radiographic Inspection (RT)	OQE as required by specification.	NA
		d. Ultrasonic Inspection (UT)	OQE as required by specification.	NA
		e. Liquid Penetrant Inspection (PT)	OQE as required by specification.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
4. Material Forming (Structural)	NAVSEA DWGs (identified by number) NAVSEA S9074-AB-MMO-010	Magnetic Particle Inspection (MT)	OQE of acceptable magnetic particle inspection (MT) of prepared surface (if MT cannot be accomplished, PT is required).	NA
5. Heat Treatment	NAVSEA DWGs (identified by number) NAVSEA S9074-AB-MMO-010 Viewports: ASME PVHO-1		OQE to show material was heat treated to temperature and times specified in material specification.	NA
		a. Visual Inspection (VT)	OQE as required by specification.	NA
		b. Magnetic Particle Inspection (MT)	OQE as required by specification.	NA
		c. Radiographic Inspection (RT)	OQE as required by specification.	NA

PART I - STRUCTURAL INTEGRITY (PRESSURE HULL, HARD STRUCTURE & APPURTENANCES)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
D. QUALIFICATIONS				
1. Personnel	VB/HP Spheres: NAVSEA SS800-AG-MAN-010/P9290 Main Support Framing, Lifting Tee: ASME sec IX QW 201.2	NDT Inspector Qualifications Welder and Operator Qualifications	OQE to document that welding, brazing and NDT personnel were qualified for the process used at the time of use.	NA
2. Equipment	Electrical Penetrators, Release Shaft, VB/HP Spheres, Main Support Framing, Lifting Tee: NAVSEA SS800-AG-MAN-010/P9290	NDT/Test Equipment Qualified/Calibrated	OQE to document that NDT equipment used was qualified and calibrated at time of use.	Wrench/gage calibrations OQE
3. Procedures	Viewports: Maintenance Manual Electrical Penetrators: NAVSEA SS800-AG-MAN-010/P9290 Release Shaft, VB/HP Spheres: NAVSEA P-9290.1A Main Support Framing, Lifting Tee: ASME sec IX QW 201.2	a. Welding Procedure Qualification Covering all Procedures	Approved welding procedures with qualification test data equivalent to that required by NAVSEA S9074-AR-GIB-010/278	NA
		b. Procedures Available Governing the NDT Operations	Approved NDT procedures equivalent to those required by NAVSEA T9074-AS-GIB-010/271	NA

PART I - STRUCTURAL INTEGRITY (PRESSURE HULL, HARD STRUCTURE & APPURTENANCES)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
E. TEST PERFORMANCE AND INSPECTION				
1. Integrity Testing and Inspection	NAVSEA SS800-AG-MAN-010/P9290 NAVSEA DWGs (identified by number) NAVSEA S9074-AB-MMO-010	Testing Completion	OQE that all related SOC testing has been completed, reviewed and approved by the cognizant authority.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
2. Load Test	NAVSEA SS800-AG-MAN-010/P9290 NAVSEA S9074-AB-MMO-010	Equipment Testing	OQE to prove handling equipment has been load tested (static and dynamic, as required) at regular intervals	NA
F. RELATED MAINTENANCE AND REPAIRS	NAVSEA SS800-AG-MAN-010/P9290	Performance of preventive maintenance and repairs within the SOC	OQE to show that required maintenance was satisfactorily accomplished and repairs within the SOC were accomplished in accordance with the requirements (MIPs/MRCs).	Completed PMS/RECs: Personnel Sphere: REC Nos. Viewports: NA Hatch: NA Electrical Hull Fittings: REC Nos. Main Support Framing: REC Nos. UT/VT/PT MBT Flask/ VB Tanks: REC Nos. Single Point Lift: REC Nos. Buoyancy Material & Attachment Devices: REC Nos.

ITEM/SURVEY ACCOUNTABILITY

PIPING SYSTEMS AND COMPONENTS - II

	ITEMS TO BE SURVEYED	HP AIR SYSTEM (HARD PIPE)	VB SYSTEM (HARD PIPE)	MANIPULATOR JETTISON	O_2 SYSTEM	EB SYSTEM	O_2 /CO_2 MONITORS	OXYGEN BOTTLES & REGULATORS	CO_2 REMOVAL SYSTEM	DRAEGER ANALYZER	FIRE EXTINGUISHER	MECH DEPTH GAUGE		REMARKS
A	DESIGN AND CONFIGURATION MANAGEMENT													
	1. DRAWING AND DESIGN DOCUMENTATION	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	2. SAFETY ANALYSIS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	3. VERIFICATION OF AS-BUILT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	4. TEST PROCEDURES AND DOCUMENTATION	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
B	MATERIAL CONTROL													
	1. MATERIAL PROPERTIES	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	2. MATERIAL IDENTIFICATION	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	3. TRACEABILITY	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
C	FABRICATION AND PROCESS CONTROL													
	1. JOINT FIT-UP AND PREPARATION	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	2. DIMENSION CONTROL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	3. PIPING AND COMPONENT JOINTS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	4. MATERIAL FORMING	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	5. HEAT TREATMENT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	6. JOINT ASSEMBLY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	7. CLEANLINESS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
D	QUALIFICATIONS													
	1. PERSONNEL WELD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	2. PERSONNEL NDT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	3. PERSONNEL CLEANING	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	4. EQUIPMENT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	X		Test equipment Calibrations - Same as section IC2 (Gages & wrenches)
	5. PROCEDURES	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
E	TEST PERFORMANCE													
	1. PIPING AND SYSTEMS TESTING	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	2. HYDROSTATIC TESTING	X	X	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	3. OPERATIONAL TEST	X	X	NA	NA	NA	NA	NA	NA	NA	NA	NA		

ITEM/SURVEY ACCOUNTABILITY

PIPING SYSTEMS AND COMPONENTS - II

ITEMS TO BE SURVEYED		HP AIR SYSTEM (HARD PIPE)	VB SYSTEM (HARD PIPE)	MANIPULATOR JETTISON	O_2 SYSTEM	EB SYSTEM	O_2 /CO_2 MONITORS	OXYGEN BOTTLES & REGULATORS	CO_2 REMOVAL SYSTEM	DRAEGER ANALYZER	FIRE EXTINGUISHER	MECH DEPTH GAUGE	REMARKS
LISTED BELOW ARE RECs OPENED SINCE LAST SURVEY													
F	RELATED MAINTENANCE/ REPAIRS	X	X	X	X	X	NA	NA	NA	NA	NA	NA	RECs 666, 668, 670, 673-676, 678, 679, 681, 682, 001-93 through 005-93, 007-93, 008-93, 010-93 through 013-93, 040-93 through 051-93, 055-93 through 058-93, 061-93, 062-93, 064-93 through 066-93, 001-94 through 006-94, 008-94
		670	675	676	673	666							
		674	682	010-93	678	668							
		004-93	013-93	012-93	679	003-93							
		007-93	040-93		681	002-94							
		011-93	041-93		001-93								
		055-93	042-93		002-93								
		056-93	043-93		005-93								
		057-93	044-93		008-93								
		058-93	045-93		001-94								
		064-93	046-93		006-94								
		065-93	047-93		008-94								
		066-93	048-93										
			049-93										
			050-93										
			051-93										
			061-93										
			062-93										
			003-94										
			004-94										
			005-94										

PART II - PIPING SYSTEMS AND COMPONENTS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
A. DESIGN AND CONFIGURATION MANAGEMENT				
1. Drawing and Design Documentation	NAVSEA SS800-AG-MAN-010/P9290	Drawing and Design Documentation Development and Review	OQE to document that the SOC has been identified and that the initial SOC design including all changes (alterations, modifications, field changes etc.) affecting the form, fit or function of the SOC have been approved by NAVSEA. Calculations to show collapse pressure, stress levels and minimum wall thickness. The OQE will document the SOC design development and approval showing that design requirements were defined and that NAVSEA approval of the design, including reviews of design, material used, calculations, analysis, test reports, safety reviews, etc. Confirmation that the approved design and changes have been incorporated into system drawings and documentation (i.e., Drawings, TABs, Valve Manuals, SIBs, SOC Notebook, etc.). Drawing indexes are up to date. Verification that the drawing index correctly identifies the SOC Top Level drawings and diagrams and the lower tier drawings correctly invoke SOC requirements. The lower tier drawing review will verify that SOC and certification requirements contained in the Top Level drawings and diagrams have not been expanded or new requirements initiated in these drawings.	NA
2. Safety Analysis (FEMA)	NAVSEA SS800-AG-MAN-010/P9290	Safety Analysis (Fault Hazard, Fault Tree, System Hazard Analysis, etc.) to show effect of change on personnel safety	OQE to verify a Safety Analysis has been prepared to include changes, additions or deletions to systems and has appropriate approval.	NA
3. Verification of As-built	NAVSEA SS800-AG-MAN-010/P9290	System Installed in accordance with Approved Drawings	System installed in accordance with approved drawings. Documentation which supports compliance with drawings including latest applicable revision to which verification was accomplished.	NA
4. Test Procedures and Documentation	NAVSEA SS800-AG-MAN-010/P9290	Test Procedures and Revision Review	OQE to verify SOC test procedures have been identified, reflect the approved design, and have been approved by NAVSEA.	NA

PART II - PIPING SYSTEMS AND COMPONENTS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
B. MATERIAL CONTROL				
1. Material Properties	NAVSEA SS800-AG-MAN-010/P9290	Verification of Material (VM)	OQE to verify that material installed meets specification/drawing requirements (e.g., correct material type, acceptable chemical and mechanical test results, unique test requirements, dimensional requirements, etc.)	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
2. Material Identification	NAVSEA SS800-AG-MAN-010/P9290	Material Marking	Appropriate unique markings that identify the material to the applicable test reports.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
3. Traceability	NAVSEA SS800-AG-MAN-010/P9290	Material Traceability Records	Fabrication records document unique material identification control numbers which provide traceability to receipt inspection data for material installed.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
C. FABRICATION AND PROCESS CONTROL				
1. Joint Fit-up and Preparation	NAVSEA S9074-AR-GIB-010/278, NAVSEA 0900-LP-001-7000, NAVSEA DWGs (identified by number) Activity Process Instruction	Visual Inspection (VT)	OQE of acceptable clearances, alignment, material, joint type, preparation and cleanliness as required by NAVSEA S9074-AR-GIB-010/278 for welding and NAVSEA 0900-LP-001-7000 for sil-brazing.	NA
2. Dimensional Control	NAVSEA S9074-AR-GIB-010/278, MIL-STD-1627	Visual Inspection (VT)	OQE of acceptable dimensional inspection results (e.g., thickness, roundness, bend radius etc.)	NA
3. Piping and Component Joints	NAVSEA S9074-AR-GIB-010/278, NAVSEA 0900-LP-001-7000, NAVSEA DWGs (identified by number)	Visual Inspection (VT)	OQE that welding performed as required by NAVSEA S9074-AR-GIB-010/278 or brazed as required by NAVSEA 0900-LP-001-7000, joint identification records and weld maps or equivalent, indicating that the joints were fabricated as required by approved drawings.	NA

PART II - PIPING SYSTEMS AND COMPONENTS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
4. Material Forming	NAVSEA S9074-AR-GIB-010/278	Magnetic Particle Inspection (MT)	OQE of acceptable magnetic particle inspection (MT) of prepared surface (if MT cannot be accomplished, PT is required).	NA
5. Heat Treatment	NAVSEA S9074-AR-GIB-010/278		OQE to show material was heat treated to temperature and times specified in the material specification.	NA
		a. Visual Inspection (VT)	OQE as required by NAVSEA S9074-AR-GIB-010/278.	NA
		b. Magnetic Particle Inspection (MT)	OQE as required by NAVSEA S9074-AR-GIB-010/278.	NA
		c. Radiographic Inspection (RT)	OQE as required by NAVSEA S9074-AR-GIB-010/278.	NA
6. Joint Assembly	NAVSEA S9505-AM-GYD-010	Visual Inspection (VT)	Verification for proper mechanical joint torque.	NA
7. Cleanliness	NAVSEA SS800-AG-MAN-010/P9290, MIL-STD-1330C, MIL-STD-1622A	Appropriate Cleaning Conducted	OQE as required by this manual.	NA
D. QUALIFICATIONS				
1. Personnel weld	MIL-STD-410, NAVSEA T9074-AS-GIB-010/271, NAVSEA S9074-AQ-GIB-010/248	Welder Qualification	OQE to document that welding personnel were qualified for the process used at the time of use.	NA
2. Personnel NDT	NAVSEA T9074-AS-GIB-010/271	Operator and Inspector Qualification	OQE to document that inspectors were qualified for the process at the time of use IAW NAVSEA T9074-AS-GIB-010/271.	NA
3 Personnel cleaning	MIL-STD-1330	Oxygen Clean Worker Qualification	OQE to document that cleaning personnel were qualified at the time of use IAW MIL-STD-1330.	NA

PART II - PIPING SYSTEMS AND COMPONENTS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
4. Equipment	MIL-I-25135E NAVSEA T9074-AS-GIB-010/271	NDT Equipment Periodically Calibrated	OQE to document that NDT equipment used was qualified and calibrated at the time of use.	Test Equipment Calibrations - Same as section IC2 (Gages & wrenches)
5. Procedures	NAVSEA S9074-AR-GIB-010/278 NAVSEA S9074-AQ-GIB-010/248	Written Procedures Covering all Welding and Brazing Processes	Approved welding and brazing procedures with qualification test data equivalent to that required by NAVSEA S9074-AQ-GIB-010/248.	NA
	ASTM E165, NAVSEA T9074-AS-GIB-010/271	Procedures Available Governing the NDT Operations	Approved NDT procedures equivalent to those required by NAVSEA T9074-AS-GIB-010/271.	NA
	MIL-STD-1627	Procedures Available	Approved procedures equivalent to those required by MIL-STD-1627.	NA
E. TEST PERFORMANCE				
1. Piping and Systems Testing	NAVSEA SS800-AG-MAN-010/P9290	Piping and Systems Testing Completion	OQE that all related SOC testing has been completed, reviewed and approved by the cognizant authority.	NA
2. Hydrostatic Testing	NAVSEA SS800-AG-MAN-010/P9290	Hydrostatic Testing Completion	OQE to document satisfactory completion of strength and tightness test (e.g., leak test, hydro test, pressure drop, seat tightness, joint tightness) as required by the applicable specifications.	Completed Test Procedure
3. Operational Test	NAVSEA SS800-AG-MAN-010/P9290	Operational, Proof and Cleanliness Flush Completion	OQE to document satisfactory completion of operational and/or proof testing and required cleanliness flushes.	Completed Test Procedure
F. RELATED MAINTENANCE AND REPAIRS	NAVSEA SS800-AG-MAN-010/P9290	Performance of preventive maintenance and repairs within the SOC.	OQE to show that required maintenance was satisfactorily accomplished and repairs within the SOC were accomplished in accordance with requirements.	Completed PMS/RECs: HP Air: REC No's., PMS Cards VB System: REC No's,. PMS Cards Manipulator Jettison: REC No's. O_2 System: REC Nos. EB System: REC No's., PMS Cards

ITEM/SURVEY ACCOUNTABILITY

ELECTRICAL AND COMMUNICATIONS - III

	ITEMS TO BE SURVEYED	CTFM	JETTISON SYSTEMS	EXTERIOR LIGHTING	VHF RADIOS	UQC & TRANSDUCERS	DEPTH DETECTORS	EMERGENCY BATTERIES	EMERGENCY POWER DISTR	ELECT CIRCUIT PROTECTIVE DEVICES	MBT BLOW SYSTEM ELECTRICAL	O_2 & EB SYSTEM ELECTRICAL	A/D SONAR	REMARKS
A	DESIGN AND CONFIGURATION MANAGEMENT													
	1. DRAWING AND DESIGN DOCUMENTATION	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	2. SAFETY ANALYSIS	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	3. TEST PROCEDURES AND DOCUMENTATION	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
B	MATERIAL CONTROL													
	1. MATERIAL PROPERTIES	NA	X	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	2. MATERIAL IDENTIFICATION	NA	X	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	3. TRACEABILITY	NA	X	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
C	FABRICATION AND PROCESS CONTROL													
	1. INSTALLATION	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
D	QUALIFICATIONS													
	1. EQUIPMENT	NA	NA	NA	NA	NA	NA	NA	NA	NA	X	NA	NA	
E	TEST PERFORMANCE													
	1. COMPONENT MATERIAL TEST	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	2. OPERATIONAL TEST	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	3. INSULATION TESTING	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4. HYDROSTATIC TESTING	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	

ITEM/SURVEY ACCOUNTABILITY

ITEMS TO BE SURVEYED	CTFM	JETTISON SYSTEMS	EXTERIOR LIGHTING	VHF RADIOS	UQC & TRANSDUCERS	DEPTH DETECTORS	EMERGENCY BATTERIES	EMERGENCY POWER DISTR	ELECT CIRCUIT PROTECTIVE DEVICES	MBT BLOW SYSTEM ELECTRICAL	O_2 & EB SYSTEM ELECTRICAL	A/D SONAR	REMARKS
LISTED BELOW ARE RECs OPENED SINCE LAST SURVEY													
F RELATED MAINTENANCE/ REPAIRS	NA	X	NA	NA	NA	NA	NA	NA	X	NA	NA	NA	RECs 667, 669, 677, 680, 683, 006-93, 009-93, 014-93 through 016-93, 059-93, 067-93, 007-94
		667							059-93				
		669											
		677											
		680											
		683											
		006-93											
		009-93											
		014-93											
		015-93											
		016-93											
		067-93											
		007-94											

PART III - ELECTRICAL AND COMMUNICATIONS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
A. DESIGN AND CONFIGURATION MANAGEMENT				
1. Drawing and Design Documentation	NAVSEA SS800-AG-MAN-010/P9290	Drawing and Design Documentation Development and Review	OQE to document that the SOC has been identified and that the initial SOC design including all changes (alterations, modifications, field changes, etc.) affecting the form, fit or function of the SOC have been approved by NAVSEA. Calculations to show collapse pressure, stress levels and minimum thickness. The OQE will document the SOC design development and approval showing that design requirements were defined and that NAVSEA approval of the design, including reviews of design, material used, calculations, analysis, test reports, safety reviews, etc. Confirmation that the approved design and changes have been incorporated into system drawings and documentation (i.e., Drawings, TABs, Valve Manuals, SIBs, SOC Notebook, etc.). Drawing indexes are up to date. Verification that the drawing index correctly identifies the SOC Top Level drawings and diagrams and the lower tier drawings correctly invoke SOC requirements. The lower tier drawing review will verify that SOC and certification requirements contained in the Top Level drawings and diagrams have not been expanded or new requirements initiated in these drawings.	S/A 225: NAVSEA approved drawings (identified by number)
2. Safety Analysis (FEMA)	NAVSEA SS800-AG-MAN-010/P9290	Safety Analysis (Fault Hazard, Fault Tree, System Hazard Analysis, etc.) to show effect of change on personnel safety	OQE to verify a Safety Analysis has been prepared to include changes, additions or deletions to systems and has appropriate approval.	S/A 225 Safety Analysis Report
3. Test Procedures and Documentation	NAVSEA SS800-AG-MAN-010/P9290	Test Procedures and Revision Review	OQE to verify SOC test procedures have been identified, reflect the approved design, and have been approved by NAVSEA.	S/A 225 SAR Approval ltr.
B. MATERIAL CONTROL				
1. Material Properties	NAVSEA SS800-AG-MAN-010/P9290	Verification of Material (VM)	OQE to verify that material installed meets specification/drawing requirements (e.g., correct material type, acceptable chemical and mechanical test results, unique test requirements, etc.).	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)

PART III - ELECTRICAL AND COMMUNICATIONS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
2. Material Identification	NAVSEA SS800-AG-MAN-010/P9290	Material Marking	Appropriate unique markings that identify the material to the applicable test reports.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
3. Traceability	NAVSEA SS800-AG-MAN-010/P9290	Material Traceability Records	Fabrication records documenting unique material identification control numbers which provide traceability to receipt inspection data for material installed.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
C. FABRICATION AND PROCESS CONTROL				
1. Installation (Verification of As-Built)	NAVSEA SS800-AG-MAN-010/P9290	Visual Inspection (VT)	OQE to show that electrical power and communication systems were fabricated and installed in accordance with drawing and specification requirements.	S/A 225: NAVSEA approved drawings (identified by number)
D. QUALIFICATIONS				
1. Equipment	NAVSEA SS800-AG-MAN-010/P9290	Test Equipment Calibration	OQE to document that only approved, qualified, calibrated electrical testing equipment was utilized to perform electrical tests.	Electronic equipment calibrations
E. TEST PERFORMANCE				
1. Component/ Material Test	NAVSEA SS800-AG-MAN-010/P9290	Requirement Compliance	OQE to demonstrate electrical and electronic components and material meet the drawing and specification requirements for production type test data to ensure equipment adequacy.	S/A 225: Test Procedure
2. Operational Test	NAVSEA SS800-AG-MAN-010/P9290	Operational Test	OQE to show results of the following operational tests: (1) Satisfactory performance of all normal and/or emergency electrical control and indicating circuits. (2) Satisfactory performance of all normal and/or emergency communication equipment. (3) Satisfactory operation and response of electrical systems. (4) Satisfactory operation of electrical activated auxiliary equipment.	S/A 225: Test Procedure

PART III - ELECTRICAL AND COMMUNICATIONS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
3. Insulation Testing	NAVSEA SS800-AG-MAN-010/P9290	Insulation Testing	OQE to show results of the following insulation checks: (1) Insulation resistance to ground for all electrical cables and systems, at 500-volt potential (switches to equipment open). (2) Previous insulation resistance tests.	S/A 225: Test Procedure
4. Hydrostatic Testing	NAVSEA SS800-AG-MAN-010/P9290	Hydrostatic Testing Completion	OQE of the following testing as appropriate: (1) Hydrostatic to 1 1/2 times test depth. (2) Insulation resistance after hydrostatic (≥ 10 Megohms). (3) Continuity check.	S/A 225: Test Procedure
F. RELATED MAINTENANCE AND REPAIRS	NAVSEA SS800-AG-MAN-010/P9290	Performance of preventive maintenance and repairs within the SOC	OQE to show that required maintenance was satisfactorily accomplished and repairs within the SOC were accomplished in accordance with requirements.	Completed PMS/RECs: Jettison Systems: REC Nos. PMS Cards Elect Circuit Protective Devices: REC Nos. PMS Cards

PART IV - COMPLETION AND READINESS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
A. RE-ENTRY CONTROL				
1. Procedures	NAVSEA SS800-AG-MAN-010/P9290 COMSUBPAC-INST 4855.3	Organizational Instruction a. REC Log b. MOU	Internal procedures which implement the re-entry system in an auditable manner to include: (1) REC log (2) MOU of responsibility and agreement between all activities	Maintenance Manual REC Log MOUs signed
2. REC Forms	NAVSEA SS800-AG-MAN-010/P9290 COMSUBPAC-INST 4855.3	REC Forms and Work Package	Re-entry control forms and supporting documentation for work performed within the SOC to verify the work was planned, authorized, accomplished, inspected, tested, completed, recertified and reviewed.	REC Package
B. TEST COMPLETION STATUS	NAVSEA SS800-AG-MAN-010/P9290 COMSUBPAC-INST 4855.3	Identify All System Tests (Identify all shallow water/ tethered dives)	Provide a list of test forms/documents annotated to reflect the status of testing within the SOC including the status of all shallow water/tethered dives.	Integrated Test Plan
1. Sea Trial Agenda	NAVSEA SS800-AG-MAN-010/P9290 COMSUBPAC-INST 4855.3 CINCLANTFLT/CINC-PACFLTINST 4790.3	Sea Trial Agenda	Sea Trial Agenda, including all required at-sea testing, submitted to and approved by the cognizant authority.	Sea Trial Agenda
C. INCOMPLETE WORK	NAVSEA SS800-AG-MAN-010/P9290 COMSUBPAC-INST 4855.3	System identifies all work required and accomplished during the availability (and since the last survey)	The REC Log and maintenance schedule are annotated to reflect complete/incomplete work status.	REC Log & PMS Schedules
D. DEPARTURES FROM SPECIFICATIONS				
1. Procedures	NAVSEA SS800-AG-MAN-010/P9290 COMSUBPAC-INST 4855.3	Organization Instruction	Procedures for controlling, identifying and tracking deviations and waivers. Deviation/waiver log identifying and listing status of each deviation/waiver.	Departure Log
2. Resolution	NAVSEA SS800-AG-MAN-010/P9290 COMSUBPAC-INST 4855.3	Approved D/W Form	OQE to document satisfactory resolution and approval of each deviation/waiver.	Approved Deviation & Waiver Documents

PART IV - COMPLETION AND READINESS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
E. ACCESS TO VITAL EQUIPMENT	NAVSEA SS800-AG-MAN-010/P9290	Forces Afloat Demonstration of Satisfactory Accessibility to Vital Equipment Shipcheck to Verify Access to Vital Equipment	Verify accessibility to vital equipment (the ability to reach, read and/or operate the following equipment): (1) Emergency Electrical Power, Power Sources/ Circuits, Protective Devices, Emergency Lighting (e.g., Battle Lanterns, Flashlights, etc.) (2) Mechanical, Electrical and Hydraulic Mechanisms (3) Fire Fighting Equipment (4) Emergency Breathing Equipment (5) Jettison System Controls (e.g., Manipulators, Battery, etc.) (6) Cable cutting devices (7) Signal Devices (buoys, telephone, dye markers) (8) Shut-Off Valves (9) Readout Devices and Visual Aids (e.g., Sonar (DDIS, UQC, ADS, OAS, UOS), Depth Detectors, Monitors (e.g., O_2, CO_2) (10) Compartment Isolation (e.g., Hatches) (11) Communications (e.g., UQC, Radio, intercom) (12) Life Support Equipment (e.g., O_2, CO_2, Blowers, Draeger Tubes)	DSUINST 9091.2 Shipcheck conducted during Internal & NAVSEA Surveys
F. IMPLODABLE VOLUMES (CRITICAL)				
1. Component Evaluation	NAVSEA SS800-AG-MAN-010/P9290	Implodable Component List (Critical)	Provide a composite list of all components categorized as critical implodable volumes.	Implodable volume test.
2. Submergence Test	NAVSEA SS800-AG-MAN-010/P9290	Implodable Pressure Testing	Provide OQE of satisfactory pressure test to 1 1/2 times test depth for 10 cycles (Note: 10 minutes at greatest pressure - cycles 1-9, 1 hour at greatest pressure for cycle 10, 35 ^{0}F if applicable).	Implodable volume test.

PART IV - COMPLETION AND READINESS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
G. OPERATING AND EMERGENCY PROCEDURES			Written procedures have been developed which cover normal and emergency operations. Operating and emergency procedures, and changes to the procedures, have been approved in writing by NAVSEA.	Operations Manual Equipment Manuals Changes to Manuals (i.e., Change to Pre-Dive Jettison Circuits Continuity Checks).
1. Procedures	NAVSEA SS800-AG-MAN-010/P9290	Approved Operating Procedures	Operating Procedures. (1) Vehicle (a) Pre-Dive Check-Off Procedures (b) Diving Procedures (c) Submerged Operating Procedures (d) Surfacing Procedures (e) Post-Dive Check-Off Procedures (2) Equipment and Systems	Vehicle Information Book-VIB Ships Valves, Description, Operation & Maintenance Instructions
	NAVSEA SS800-AG-MAN-010/P9290	Emergency Procedures	(1) Emergency Procedures (a) Fire Fighting (b) Collision (c) Loss of Power (d) Component or System Failure (e) Emergency Egress	Operational Bills, Emergency Bills and Checklists
	NAVSEA SS800-AG-MAN-010/P9290	Approved Vehicle Limitations	Vehicle Operating Limitations and Precautions	Vehicle/Systems Limitations Letter of Certification
	NAVSEA SS800-AG-MAN-010/P9290	Approved System Limitations	Systems and Components Limitations, Precautions and Set Points.	
2. Test Program Verification	NAVSEA SS800-AG-MAN-010/P9290 COMSUBPAC-INST 4855.3	Procedure Verification	Test program verification of operating and emergency procedures	

PART IV - COMPLETION AND READINESS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
H. MAINTENANCE				
1. Procedures	NAVSEA SS800-AG-MAN-010/P9290	Maintenance Procedures	Written procedures have been developed which cover routine preventive maintenance. Maintenance procedures and changes to procedures have been approved in writing by NAVSEA.	Maintenance Manual Maintenance Requirements - PMS Maintenance Requirement Cards
	OPNAVINST 4790.7		(1) Maintenance, Inspection and Servicing Procedures (a) Corrective Maintenance (b) Preventive Maintenance (1) Overhaul (2) Periodic Inspection (c) Post-Repair Inspection (d) Replenishment and Post-Dive Servicing	
2. Maintenance	OPNAVINST 4790.7	Maintenance conducted within required periodicity	Provide OQE to show required maintenance has been performed at the required intervals.	PMS Schedules and RECs
I. OPERATING LOGS/RECORDS				
1. Operating Logs, Pre-Dive and Post-Dive Checklists	NAVSEA SS800-AG-MAN-010/P9290	Operating Log Review	Operating logs are complete, data is consistent, discrepancies noted during operation have been satisfactorily resolved, and there is evidence of pre-evolution briefings.	Surface Control Logs, Dive Logs, Pre-Dive and Post-Dive Checklists DSUINST 9000.2

PART IV - COMPLETION AND READINESS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
J. STABILITY AND BUOYANCY				
1. Change	NAVSEA SS800-AG-MAN-010/P9290 NSTM CHAP 096, CH1, NAVSEAINST C9096.2A	Stability and Buoyancy Change	OQE to demonstrate, where applicable, both by calculation and by test, that any weight change since last dive will not adversely affect stability for submerged, surfaced or any emergency surfacing condition.	Updated W&B calculations, Trials Agenda
2. Syntactic Foam	MINS Syntactic Foam Spec 282.11-2-90	Verification of Material (VM)	OQE that material installed meets specifications.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
K. ATMOSPHERIC CONTROL				
1. Toxic and Flammable Materials	NAVSEA SS800-AG-MAN-010/P9290	a. Material List	Provide a list of all new toxic and flammable materials (off-gassing OQE) used/introduced since last survey. * One non-metallic material was added by LESC: RAYCHEM RNF - 100 Heat Shrink material was tested and approved.	S/A 225 Toxicity and Flammability Analysis
		b. Independent Evaluation	OQE to demonstrate the suitability and adequacy of each material used.	Appropriate OQE (e.g., RECs, fabrication records, COCs, etc.)
2. Atmospheric Analysis	NAVSEA SS800-AG-MAN-010/P9290	Sampling Data	OQE to verify compliance with the atmospheric sampling and test requirements of this manual.	Results of closed boat air sample analysis
L. TEMP MODS	NAVSEA SS800-AG-MAN-010/P9290	Comply with requirements for Installation of New Systems into a DSV	OQE that the Temp Mods approved for installation meet design (safety) requirements of Section III of this manual.	Approved packages
			OQE that conditions on Temp Mods approved subject to specific action (e.g., continuity checks, IR checks, bomb samples, etc.) have been satisfied.	

NAVAL SEA SYSTEMS COMMAND

CERTIFICATION SURVEY PLAN
FOR
DEEP SUBMERGENCE SYSTEM
HANDLING SYSTEMS

SUBMITTAL:

_____ _____
BUILDER/SUSTAINING ACTIVITY DATE

_____ _____
PROGRAM MANAGER DATE

APPROVAL:

_____ _____
NAVSEA SCA DATE

DEPARTMENT OF THE NAVY
2531 JEFFERSON DAVIS HIGHWAY
ARLINGTON, VA 22242-5160

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CERTIFICATION SURVEY PLAN

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GENERAL NOTES

1. The minimum requirements contained in this survey plan in no way relieve the Program Manager, Supervising Authority/Contractor or Sustaining Activity of the responsibility for meeting the requirements of other specifications invoked by contract or other quality assurance requirements. The Program Manager shall establish and maintain an accountability system to ensure that all records required are readily available in an auditable form to support NAVSEA survey.

   Once these actions have been completed the Program Manager will submit the annotated copy of the Certification Survey Plan (CSP) to the SCA for review and approval.

2. Design parameters, calculations and analyses that have been previously satisfied need not be addressed during the survey. For alterations, modifications or other material changes, Objective Quality Evidence (OQE) documentation will be provided to verify that these items comply with the initial system certification application requirements of this manual and have received the correct technical review and approval by NAVSEA.

3. Configuration Changes. Only configuration changes within the SOC will be covered by Sections A, B, C, D, and E of Part I, Sections A, B, C, and D of Part II, and Sections A and B of Part III of the CSP. All maintenance, repair and replacement work will be covered by Section F of Part I, Section E of Part II, Section C of Part III, and Part IV of the CSP.

4. Maintenance/Repair Items Requiring Re-Entry Control. Maintenance and repair items requiring Re-Entry Control (REC) are addressed in the last sections of Parts I, II and III. Maintenance items that do not require REC are covered in Part IV of this survey plan.

5. Related Maintenance and Repairs accomplished since the last survey are identified for each system within the SOC. As a minimum, the auditor shall take the following action:

   Related Maintenance. The auditor will review the work package for the maintenance and verify that all required maintenance action within the SOC has been satisfactorily accomplished and is properly documented.

   Repair. The auditor will review the work package (if applicable) and ensure OQE is available to show compliance with each “applicable” line item attribute of the CSP. Application of the CSP line item attribute must be determined by the auditor based on actual work accomplished. For example, if pipe/tubing welding within the SOC was accomplished the review would include the attributes from the “Fabrication and Process Control” section (e.g., Joint Fit-up and Preparation, Piping and Component Welding, etc.), the “Material Control” section, the “Qualification” section (e.g., Weld and NDT Personnel and Procedures Qualification, etc.).

ITEM/SURVEY ACCOUNTABILITY

STRUCTURAL INTEGRITY (LOAD BEARING COMPONENTS) - I

	ITEMS TO BE SURVEYED	MAIN LIFT LINE -SYNTHETIC	MAIN LIFT -WIRE ROPE	END FITTINGS	SHEAVES/ REEVING COMPONENTS	WINCH DRUM	MAIN STRUCTURE ASSEMBLY	STRUCTURAL FASTENERS	FOUNDATIONS (ABOVE DECK)	SUPPORTING SHIP STRUCTURE (BELOW DECK)	HYDRAULIC CYLINDERS	LATCH/PINS	REMARKS
A	DESIGN AND CONFIGURATION MANAGEMENT												
	1. DRAWING AND DESIGN DOCUMENTATION	X	X	X	X	X	X	X	X	X	X	X	
	2. SAFETY ANALYSIS	X	X	X	X	X	X	X	X	X	X	X	
	3. VERIFICATION OF AS-BUILT	X	X	X	X	X	X	X	X	X	X	X	
	4. TEST PROCEDURES AND DOCUMENTATION	X	X	X	X	X	X	X	X	X	X	X	
B	MATERIAL VERIFICATION												
	1. MATERIAL PROPERTIES	X	X	X	X	X	X	X	X	X	X	X	
	2. MATERIAL IDENTIFICATION	X	X									X	
	3. TRACEABILITY	X	X			X	X	X	X			X	
C	FABRICATION AND PROCESS CONTROL												
	1. STRUCTURAL WELDS						X		X	X			
D	QUALIFICATIONS												
	1. PERSONNEL						X		X	X			
	2. EQUIPMENT						X		X	X			
	3. PROCEDURES						X		X	X			
E	TEST PERFORMANCE AND INSPECTIONS												
	1. STATIC LOAD TEST (2X RATED LOAD)	X	X	X	X	X	X	X	X	X	X	X	
	2. DYNAMIC LOAD TEST (1.5X RATED LOAD)				X						X		
	3. RATED LOAD TEST (1X RATED LOAD)				X						X		
	4. CERTIFICATE OF BREAK TEST (MAIN LIFT LINE)	X	X										
	5. PROOF TEST			X									
	6. NDT AFTER LOAD TESTS						X		X				
F	RELATED MAINTENANCE/REPAIRS	X	X	X	X	X	X	X	X	X	X	X	

PART I - STRUCTURAL INTEGRITY (LOAD BEARING COMPONENTS)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
A. DESIGN AND CONFIGURATION MANAGEMENT				
1. Drawing and Design Documentation	NAVSEA SS800-AG-MAN-010/P9290	Drawing and Design Documentation Development and Review	OQE to document that the SOC has been identified and that the initial SOC design including all changes (alterations, modifications, field changes etc.) affecting the form, fit or function of the SOC have been approved by NAVSEA. The OQE will document the SOC design development and approval showing that design requirements were defined and that NAVSEA approval of the design, including reviews of design, material used, calculations, analysis, test reports, safety reviews, etc. Confirmation that the approved design and changes have been incorporated into system drawings and documentation. Drawing indexes are up to date. Verification that the drawing index correctly identifies the SOC Top Level drawings and diagrams and the lower tier drawings correctly invoke SOC requirements. The lower tier drawing review will verify that SOC and certification requirements contained in the Top Level drawings and diagrams have not been expanded or new requirements initiated in these drawings.	For supporting ship structure, ABS approval must be provided.
2. Safety Analysis (FEMA)	NAVSEA SS800-AG-MAN-010/P9290	Safety Analysis (Fault Hazard, Fault Tree, System Hazard Analysis, etc.) to show effect of change on personnel safety	OQE to verify a Safety Analysis has been prepared to include changes, additions or deletions to systems and has appropriate approval.	ABS Certification for foundations and supporting ship structure.
3. Verification of As-built	NAVSEA SS800-AG-MAN-010/P9290 and DSS Support Ship Annual Survey Plan	Visual Inspection System	System installed in accordance with approved drawings. Documentation which supports compliance with drawings including latest applicable revision to which verification was accomplished.	For supporting ship structure, ABS approval must be provided. SCA on-site survey of existing equipment. OQE for torquing of fasteners.
4. Test Procedures and Documentation	NAVSEA SS800-AG-MAN-010/P9290	Test Procedures and Revision Review	OQE to verify SOC test procedures have been identified, reflect the approved design, and have been approved by NAVSEA.	Completed Test Procedures.

PART I - STRUCTURAL INTEGRITY (LOAD BEARING COMPONENTS)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
B. MATERIAL VERIFICATION				
1. Material Properties		Verification of Material (VM)	OQE that material installed meets specification/drawing requirements (e.g., correct P/N material type, unique test requirements). For synthetic ropes used to support the DSS this includes: (a) fiber type (b) size (c) length (d) breaking strength (e) construction For wire ropes used to support the DSS this includes: (a) size (diameter) (b) length (c) direction and type of lay (d) breaking strength (e) construction and grade For end fittings this includes: (a) In accordance with applicable drawing (b) Installed by qualified personnel (c) Were proof tested after installed on rope to 200 percent of the rated load of the system, or 40 percent of the breaking strength of the rope.	ABS Classification for Deck Structure and Under Deck Structure. Documentation of fastener materials including mechanical and chemical properties and marking of fasteners.
2. Material Identification	NAVSEA SS800-AG-MAN-010/P9290	Material Marking	Appropriate unique markings that identify the material to the applicable drawings.	ABS Classification for Deck Structure and Under Deck Structure.
3. Traceability	NAVSEA SS800-AG-MAN-010/P9290	Material Traceability Records	Fabrication records documenting unique material identification control numbers which provide traceability to receipt inspection data for material installed. For synthetic and wire ropes this includes documentation that shows the installed rope was proof tested, and is traceable to the sample that was pulled to failure to obtain the certification of break.	ABS Classification for Deck Structure and Under Deck Structure. SCA verify proper markings of fasteners.

PART I - STRUCTURAL INTEGRITY (LOAD BEARING COMPONENTS)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
C. FABRICATION AND PROCESS CONTROL				
1. Structural Welds (Full and Partial Penetration Welds)	NAVSEA SS800-AG-MAN-010/P9290 and DSS Handling System Drawings	a. Visual Inspection (VT)	OQE if required by drawings.	ABS Classification for above deck and under deck structure.
		b. Magnetic Particle Inspection (MT)	OQE if required by drawings.	
		c. Liquid Penetrant Inspection (PT)	OQE if required by drawings.	
D. QUALIFICATIONS				
1. Personnel	NAVSEA SS800-AG-MAN-010/P9290	NDT Inspector Qualifications Welder and Operator Qualifications	OQE to document that welding and NDT personnel were qualified for the process used at the time of use.	ABS Classification for above deck and under deck structure.
2. Equipment		NDT/Test Equipment Qualified/Calibrated	OQE to document that NDT equipment used was qualified and calibrated at time of use.	
3. Procedures		a. Welding Procedure Qualification Covering all Procedures	Approved welding procedures with qualification test data equivalent to that required by NAVSEA S9074-AR-GIB-010/278 or equivalent.	ABS Classification for above deck and under deck structure.
		b. Procedures Available Governing the NDT Operations	Approved NDT Procedures equivalent to those required by NAVSEA T9074-AS-GIB-010/271 or equivalent.	ABS Classification for above deck and under deck structure.

PART I - STRUCTURAL INTEGRITY (LOAD BEARING COMPONENTS)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
E. TEST PERFORMANCE AND INSPECTIONS				
1. Static Load Test	NAVSEA SS800-AG-MAN-010/P9290	Equipment Testing	OQE to show handling equipment has been load tested at 200 percent, 150 percent, 100 percent of the rated load at regular intervals.	Test Doc. No's. NAVSEA Review and Witness Test
2. Dynamic Load Test	NAVSEA SS800-AG-MAN-010/P9290	Equipment Testing	OQE to show the synthetic or wire rope meets design requirements. The break test shall be in accordance with FED-STD-191, CI STD Test method, or ASTM D4268 for synthetic ropes and FED-STD-191 for wire ropes.	Test Doc. No's. NAVSEA Review and Witness Test
3. Rated Load Test	NAVSEA SS800-AG-MAN-010/P9290	Equipment Testing	OQE to show the lifting ropes have been tested to 200 percent of the rated capacity of the DSS handling system. This is to ensure the end fittings or splice has been installed properly. It also ensures the rope has not been degraded during storage.	Test Doc. No's. NAVSEA Review and Witness Test
4. Certification of Break	NAVSEA SS800-AG-MAN-010/P9290	Equipment Testing	OQE to prove requirements of Appendix H have been met.	Test records from testing facility.
5. Proof test	NAVSEA SS800-AG-MAN-010/P9290	Equipment Testing	Pull tests on end fittings.	Approved test procedure or test records from testing facility.
6. NDT after load tests	NAVSEA SS800-AG-MAN-010/P9290	Equipment Testing	OQE showing satisfactory PT or MT inspection of selected welds in the load path.	PT or MT inspection results.
F. RELATED MAINTENANCE AND REPAIRS	NAVSEA SS800-AG-MAN-010/P9290	Performance of preventive maintenance and repairs within the SOC	OQE to show that required maintenance was satisfactorily accomplished and repairs within the SOC were accomplished in accordance with requirements (MIPs/MRCs).	List of Maintenance Documents

ITEM/SURVEY ACCOUNTABILITY

PIPING SYSTEMS AND COMPONENTS (LOAD CONTROLLING) - II

ITEMS TO BE SURVEYED		CB VALVES	RELIEF VALVES	HYDRAULIC CYLINDERS	WINCH MTR	MISCELLANEOUS PIPING & VALVES	HPU	CONTROLS ON CONSOLE						REMARKS
A	DESIGN AND CONFIGURATION MANAGEMENT													
	1. DRAWING AND DESIGN DOCUMENTATION	X	X	X	X	X	X	X						
	2. SAFETY ANALYSIS	X	X	X	X	X	X	X						
	3. VERIFICATION OF AS-BUILT	X	X	X	X	X	X	X						
	4. TEST PROCEDURES AND DOCUMENTATION					X	X	X						
B	MATERIAL CONTROL													
	1. MATERIAL IDENTIFICATION	X	X	X	X									
	2. TRACEABILITY													
C	FABRICATION AND PROCESS CONTROL													
	1. CLEANLINESS	X	X	X	X	X	X							
D	TEST PERFORMANCE													
	1. HYDROSTATIC TESTING			X	X	X	X							
	2. OPERATIONAL TEST	X	X	X	X	X	X	X						
	3. CRACKING PRESS VERIFICATION	X	X											
	4. SEAT TIGHTNESS TEST	X	X											
E	RELATED MAINTENANCE AND REPAIRS	X	X	X	X	X	X	X						List of Maintenance Documents

PART II - PIPING SYSTEMS AND COMPONENTS (LOAD CONTROLLING)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
A. DESIGN AND CONFIGURATION MANAGEMENT				
1. Drawing and Design Documentation	NAVSEA SS800-AG-MAN-010/P9290	Drawing and Design Documentation Development and Review	OQE to document that the SOC has been identified and that the initial SOC design including all changes (alterations, modifications, field changes etc.) affecting the form, fit or function of the SOC have been approved by NAVSEA. The OQE will document the SOC design development and approval showing that design requirements were defined and that NAVSEA approval of the design, including reviews of design, material used, calculations, analysis, test reports, safety reviews, etc. Confirmation that the approved design and changes have been incorporated into system drawings and documentation. Drawing indexes are up to date. Verification that the drawing index correctly identifies the SOC Top Level drawings and diagrams and the lower tier drawings correctly invoke SOC requirements. The lower tier drawing review will verify that SOC and certification requirements contained in the Top Level drawings and diagrams have not been expanded or new requirements initiated in these drawings.	SCA Review of Hydraulic DWGs. Activity Management Plan For HPU, Controls, and Misc. Piping Valves. Drawing No's.
2. Safety Analysis (FEMA)	NAVSEA SS800-AG-MAN-010/P9290	Safety Analysis (Fault Hazard, Fault Tree, System Hazard Analysis, etc.) to show effect of change on personnel safety	OQE to verify a Safety Analysis has been prepared to include changes, additions or deletions to systems and has appropriate approval.	SCA Review FEMA
3. Verification of As-built	NAVSEA SS800-AG-MAN-010/P9290	System Installed in accordance with Approved Drawings	System installed in accordance with approved drawings. Documentation which supports compliance with drawings including latest applicable revision to which verification was accomplished.	SCA Review FEMA
4. Test Procedures and Documentation	NAVSEA SS800-AG-MAN-010/P9290	Test Procedures and Revision Review	OQE to verify SOC test procedures have been identified, reflect the approved design, and have been approved by NAVSEA.	

PART II - PIPING SYSTEMS AND COMPONENTS (LOAD CONTROLLING)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
B. MATERIAL CONTROL				
1. Material Identification	NAVSEA SS800-AG-MAN-010/P9290	Material Marking	Manufacturer and P/N or appropriate unique markings that identify the material to the appropriate drawings.	NA
2. Traceability	NAVSEA SS800-AG-MAN-010/P9290	Material Traceability Records	Fabrication records document unique material identification control numbers which provide traceability to receipt inspection data for material installed.	NA
C. FABRICATION AND PROCESS CONTROL				
1. Cleanliness	NAVSEA SS800-AG-MAN-010/P9290	Appropriate Cleaning Conducted	OQE as required by this manual.	SCA Verifies requirements are met
D. TEST PERFORMANCE				
1. Hydrostatic Testing	NAVSEA SS800-AG-MAN-010/P9290	Hydrostatic Testing Completion	OQE to document satisfactory completion of strength and tightness test (e.g., leak test, hydrostatic test, joint tightness) as required by the applicable specifications.	Completed Test Memos.
2. Operational Test	NAVSEA SS800-AG-MAN-010/P9290	Operational, Proof and Cleanliness Flush Completion	OQE to document satisfactory completion of operational and/or proof testing and required cleanliness flushes.	SCA Witness and Review of Test Results.
3. Cracking Press Verification	NAVSEA SS800-AG-MAN-010/P9290	For CB Valves Relief Valves	OQE to document satisfactory completion of tests that show counter balance valves and relief valves operate as designed. Note: For relief valves, this can be accomplished when adjusting the system during installation or maintenance.	Verification Tests of Overhauled Valves.
4. Seat Tightness Test	NAVSEA SS800-AG-MAN-010/P9290	For CB Valves Relief Valves	OQE to document proper operation of counter balance valves and relief valves operate as designed. Note: For relief valves, this can be accomplished when adjusting the system during installation or maintenance.	Verification Tests of Overhauled Valves.
E. RELATED MAINTENANCE AND REPAIRS	NAVSEA SS800-AG-MAN-010/P9290	Performance of preventive maintenance and repairs within the SOC	OQE to show that required maintenance was satisfactorily accomplished and repairs within the SOC were accomplished in accordance with requirements.	List Related Maintenance Documents

ITEM/SURVEY ACCOUNTABILITY

ELECTRICAL AND COMMUNICATIONS (LOAD CONTROLLING) - III

	ITEMS TO BE SURVEYED	ELECTRIC MOTORS IN HPU	CONTROLS: NORMAL	WIRING AND COMPONENTS										REMARKS
A	DESIGN AND CONFIGURATION MANAGEMENT													
	1. DRAWING AND DESIGN DOCUMENTATION		X											
	2. SAFETY ANALYSIS	X	X	X										
	3. TEST PROCEDURES AND DOCUMENTATION		X											
B	TEST PERFORMANCE													
	1. OPERATIONAL TEST	X	X	X										
C	RELATED MAINTENANCE AND REPAIRS	X	X	X										Related Maintenance Documents

PART III - ELECTRICAL AND COMMUNICATIONS (LOAD CONTROLLING)

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
A. DESIGN AND CONFIGURATION MANAGEMENT				
1. Drawing and Design Documentation	NAVSEA SS800-AG-MAN-010/P9290	Drawing and Design Documentation Development and Review	OQE to document that the SOC has been identified and that the initial SOC design including all changes (alterations, modifications, field changes etc.) affecting the form, fit or function of the SOC have been approved by NAVSEA. The OQE will document the SOC design development and approval showing that design requirements were defined and that NAVSEA approval of the design, including reviews of design, material used, calculations, analysis, test reports, safety reviews, etc. Confirmation that the approved design and changes have been incorporated into system drawings and documentation. Verification that the drawing index correctly identifies the SOC Top Level drawings and diagrams and the lower tier drawings correctly invoke SOC requirements. The lower tier drawing review will verify that SOC and certification requirements contained in the Top Level drawings and diagrams have not been expanded or new requirements initiated in these drawings.	SCA Review of Control Console Drawings.
2. Safety Analysis (FEMA)	NAVSEA SS800-AG-MAN-010/P9290	Safety Analysis (Fault Hazard, Fault Tree, System Hazard Analysis, etc.) to show effect of change on personnel safety	OQE to verify a Safety Analysis has been prepared to include changes, additions or deletions to systems and has appropriate approval.	SCA Review of FEMA
3. Test Procedures and Documentation	NAVSEA SS800-AG-MAN-010/P9290	Test Procedures and Revision Review	OQE to verify SOC test procedures have been identified, reflect the approved design, and have been approved by NAVSEA.	SCA Review of Control Console Drawings.
B. TEST PERFORMANCE				
1. Operational Test	NAVSEA SS800-AG-MAN-010/P9290	Operational Test	OQE to show results of the following operational tests: (1) Satisfactory performance of all normal electrical control and indicating circuits. (2) Satisfactory operation and response of electrical systems. (3) Satisfactory operation of electrical activated auxiliary equipment.	SCA Witness Operations During Load Tests
C. RELATED MAINTENANCE AND REPAIRS	NAVSEA SS800-AG-MAN-010/P9290	Performance of preventive maintenance and repairs within the SOC	OQE to show that required maintenance was satisfactorily accomplished and repairs within the SOC were accomplished in accordance with requirements.	Related Maintenance Documentation

PART IV - COMPLETION AND READINESS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
A. RE-ENTRY CONTROL				
1. Procedures	NAVSEA SS800-AG-MAN-010/P9290	Organizational Instruction a. Maintenance Log	Internal procedures which implement the system in an auditable manner to include: (1) Maintenance Log	Work Procedures and Logs
2. REC Forms	NAVSEA SS800-AG-MAN-010/P9290	REC Forms and Work Package	Re-entry control forms and supporting documentation for work performed within the SOC to verify the work was planned, authorized, accomplished, inspected, tested, completed, recertified and reviewed.	Work Procedures and Logs
B. TEST COMPLETION STATUS	NAVSEA SS800-AG-MAN-010/P9290	Identify All System Tests	Provide a list of test forms/documents annotated to reflect the status of testing within the SOC.	Verification during SCA Survey that all tests have been completed.
C. INCOMPLETE WORK	NAVSEA SS800-AG-MAN-010/P9290	System identifies all work required and accomplished during the availability (and since the last survey)	The Log and maintenance schedule are annotated to reflect complete/incomplete work status.	Work Procedures, ABS Certification
D. DEPARTURES FROM SPECIFICATIONS				
1. Procedures	NAVSEA SS800-AG-MAN-010/P9290	Organization Instruction	Procedures for controlling, identifying and tracking deviations and waivers. Deviation/waiver log identifying and listing status of each deviation/waiver.	Activity Management Plan Departure Nos.
2. Resolution	NAVSEA SS800-AG-MAN-010/P9290	Approved D/W Form	OQE to document satisfactory resolution and approval of each deviation/waiver.	Activity Management Plan Departure Nos.

PART IV - COMPLETION AND READINESS

ITEM TO BE SURVEYED	SPECIFICATION	DESCRIPTION OF REQUIREMENTS	DOCUMENTATION REQUIRED	DOCUMENTATION TO SUBSTANTIATE REQUIREMENTS
E. OPERATING PROCEDURES	NAVSEA SS800-AG-MAN-010/P9290	Operating Procedures	Operating Procedures	Approved NAVSEA Procedures. Review Changes to Procedures Provided
F. MAINTENANCE				
1. Procedures	NAVSEA SS800-AG-MAN-010/P9290	Maintenance Procedures	Written procedures have been developed which cover routine preventive maintenance. Maintenance procedures and changes to procedures have been approved in writing by NAVSEA. (1) Maintenance, Inspection and Servicing Procedures (a) Corrective Maintenance (b) Preventive Maintenance (1) Overhaul (2) Periodic Inspection (c) Post-Repair Inspection (d) Replenishment and Post-Dive Servicing	Maintenance Log Lift Systems Log Review and submit to NAVSEA with any changes.
2. Maintenance	NAVSEA SS800-AG-MAN-010/P9290	Maintenance conducted within required periodicity	Provide OQE to show required maintenance has been performed at the required intervals.	
G. OPERATING LOGS/RECORDS				
1. Operating Logs, Pre-Dive and Post-Dive Checklists	NAVSEA SS800-AG-MAN-010/P9290	Operating Log Review	Operating logs are complete, data is consistent, discrepancies noted during operation have been satisfactorily resolved, and there is evidence of pre-evolution briefings.	Launch and Recovery Procedures - Normal Pre-Dive and Post-Dive Checklist

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APPENDIX L

ACCESS TO AND OPERATION OF VITAL EQUIPMENT

L.1 INTRODUCTION

Access to vital components and equipment is defined as the ability to reach, read and/or operate components and equipment identified as vital to the recovery and emergency operation of a DSS. A shipcheck shall be conducted to ensure that components and equipment vital for recovery and emergency operation are readily accessible for operation. The following sections provide uniform standards for conduct of these shipchecks.

L.2 LIST OF COMPONENTS VITAL TO EMERGENCY RECOVERY

The Cognizant Technical Authority or Sustaining Activity as applicable will prepare an inspection procedure which will include a list of components and equipment vital to recovery and emergency operation for each specific DSS. The inspection procedure shall be approved by the Program Manager with SCA concurrence. This list shall be derived from the generalized groups in Table L-1 and should be developed using the recommended format of Figure L-1. It will include appropriate additions or changes based on the DSS's unique characteristics. This list will include only those normal and emergency components requiring immediate and follow-up operation to effect recovery or emergency operation of the DSS. The access times provided in Table L-1 shall be used as general guidance while developing the individual inspection procedure. The procedure, including the list, shall be prepared in the format of an Inspection Check-off Procedure similar to that depicted in Section L.5. The procedure will be referenced in the CSP as "Documentation to Substantiate Requirements" for the Access to and Operation of Vital Equipment attribute. NAVSEA will check Access to and Operation of Vital Equipment on all surveys.

L.3 INSPECTION OF DEEP SUBMERGENCE SYSTEMS

a. An inspection of each DSS shall be conducted by the builder prior to manned use, by the Sustaining Activity or industrial facility at the end of each restricted or overhaul availability, and prior to the associated SCA survey to ensure that vital components and equipment listed in the Inspection Check-Off Procedure meet the approved procedure criteria.

b. These inspections shall be conducted at or near the completion of construction of the DSS, or at or near the completion of restricted or overhaul availabilities, and as specified by the Program Manager, but prior to the SCA survey. However, scheduling should be such that sufficient time is allowed to correct all deficiencies prior to manned

use, prior to sea trials, or prior to any scheduled underway time. If the scheduled dates are not met, the inspection does not have to be repeated.

L.4 ACCESSIBILITY CONDITIONS

The following criteria are established:

a. Vital components and equipment can be reached for operation in an emergency by the watchstander who would normally operate the component or equipment. The time interval from start to finish is expressed as Time Required (TR). The starting point is from the location where the watchstander might be expected to be stationed. Guidance for establishing TR is as follows:

TR	INTERPRETATION
0 Sec	Constant manipulation access.
1 Sec	Constantly-manned panel, control board or actuator access.
2 Sec	Manifold, panel or actuator access in immediate vicinity of watch station.
10 Sec	Exposed actuator access on same level and in the same compartment as watch station. Also, exposed actuator access in adjoining compartments on small submersibles and DSSs with multiple compartments (e.g., DSRVs and DDSs) when all compartments are not normally manned during operation.
Other	As required.

b. The component to be operated shall not be enclosed nor its operation encumbered by any piping, cabling, or structural interferences.

c. Adequate grabs and ladders shall be provided, as required, to assist access during steep angles.

d. An Inspection Check-Off Procedure expanded from the sample format, Section L.5, shall be used to list the vital components and equipment for documenting the required quantitative and qualitative data.

Table L-1. Access Time Limitations - Generalized Groups of Vital Equipment

VITAL COMPONENTS AND EQUIPMENT	ACCESS TIME (Sec)
1. Emergency Electrical Power, Power Sources/Circuits, Protective Devices, Emergency Lighting (e.g., Battle Lanterns, Flashlights, etc.)	1
2. Mechanical, Electrical and Hydraulic Mechanisms	1
3. Fire Fighting Equipment	1
4. Emergency Breathing Equipment	1
5. Jettison System Controls (e.g., Manipulators, Battery, etc.)	2
6. Cable cutting devices	2
7. Signal Devices (e.g., buoys, telephone, dye markers, etc.)	10
8. Shut-Off Valves	10
9. Readout Devices and Visual Aids (e.g., Sonar (DDIS, UQC, ADS, OAS, UOS), Depth Detectors, Monitors (e.g., O_2, CO_2))	0
10. Compartment Isolation (e.g., Hatches)	10
11. Communications (e.g., UQC, Radio, intercom)	1
12. Life Support Equipment (e.g., O_2, CO_2, Blowers, Draeger Tubes)	1
NOTE: Cited examples may not apply to each vehicle/system. The applicability for each DSS must be determined based on the unique characteristics of the DSS.	

NOTE: Table L-1 and Section L.5 are provided for guidance only. It is not the intent of this section to imply that the listing of generalized components and access times apply uniformly to all DSSs. Each DSS is different and unique, and as such, DSS specific procedures will be required.

L.5 ACCESS TO VITAL EQUIPMENT AND COMPONENTS AND EQUIPMENT INSPECTION PROCEDURE

L.5.1 Objective

The purpose of this inspection is to ensure vital components and equipment that may be involved in recovery or emergency operation of a DSS are readily accessible.

L.5.2 Required Inspections

L.5.2.1 Accessibility

a. Access to and operation of the component or equipment must not be obstructed or restricted by structure, piping, machinery, or other equipment.

b. If a component or piece of vital equipment is located behind a locker front, false panel or other covering, ensure that there is adequate access to the component and that the access is clearly marked with the component location on the outside. Ensure access covers, if any, are readily removable and cannot be locked into place.

c. The component or equipment should be within arm's reach of the watchstander without his having to assume an unusual position or stretch excessively to operate the component or equipment after reaching around, through or over structure, piping or habitability coverings.

d. The function of this portion of the inspection is not to demonstrate operation of the components and equipment but to show the watchstander has unrestricted access to the components and equipment.

L.5.2.2 Access Time Check

a. The watchstander must reach vital components and equipment in the time specified.

b. The function of this portion of the inspection is not to demonstrate operation of the components and equipment but to show the watchstander can reach the components and equipment within the specified time.

L.5.3 Scheduling of Inspection

a. These inspections shall be conducted at or near the completion of construction of the DSS, or at or near the completion of restricted or overhaul availabilities, and as specified by the Program Manager, but prior to the SCA certification survey, and no earlier than 4 weeks prior to the survey for sustaining certification.

b. The inspection should be scheduled such that sufficient time is allowed to correct all deficiencies prior to sea trials or prior to any scheduled underway times.

L.5.4 General Information

a. Section L.6 and the Equipment Inspection Checklist, Figure L-1, shall be completely filled in and each entry shall be signed and dated. If information was required to be recorded by the procedure and it was omitted, an entry shall be made that explains the missing information.

b. Any discrepancies identified during the inspection shall be corrected and the affected portion of the procedure shall be performed again. If the discrepancy cannot be resolved because of operational commitments or other problems, report the facts to the Program Manager and SCA as a Major DFS.

c. Resolution of discrepancies encountered during the inspection shall be documented in the appropriate space in Section L.6 of this procedure.

d. Any departure from this inspection procedure shall be approved by the Program Manager and SCA.

L.5.5 Inspection Procedure

Verify complete installation of walkways, steps, hand grabs, stanchions, ladders, protective railings, and any other device designed for the physical support of watchstander personnel in the spaces in which the components and equipment are located.

L.5.5.1 Accessibility Inspection

Inspect each of the components listed in the checklist for accessibility and verify that access is not restricted. Place "SAT" or "UNSAT", as applicable, on the checklist for the component inspected.

L.5.5.2 Access Time Check

For each of the components listed in the checklist, measure the time required for a watchstander to reach the component and be ready to operate it. The watchstander should start from the location where they might normally be expected to be stationed. The watchstander should also be the normal operator of the component. The measured times shall be rounded up to the nearest second and recorded on the checklist.

L.6 CONCLUSION

Notes concerning the inspection - (Enter remarks and record resolution of all deficiencies identified during the inspection.)

L.6.1 Evaluation of Inspection Results

Evaluation - All discrepancies identified have been satisfactorily resolved, and Accessibility and Access Times are:

[ ] SAT [ ] UNSAT

Signature_____Title_____Date_____
Quality Assurance Officer

Signature_____Title_____Date_____
Officer in Charge

ACCESS TO VITAL COMPONENTS AND EQUIPMENT
INSPECTION CHECKLIST

DSS_____ PAGE_____OF_____

SYS	COMPONENT/EQUIPMENT	ACCESS SAT/UNSAT	ACCESS TIME REQUIRED/ACTUAL	SIGNATURE	DATE

Figure L-1

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APPENDIX M

BIBLIOGRAPHY

The publications listed below are representative of those which may be useful to the Program Manager in preparing his DSS design for material certification. Unless otherwise indicated the most recent issue or revision of each shall be used.

REFERENCE	PARAGRAPH	PAGE
ABS Rules for Building and Classing Steel Vessels	H.5.1.b(2)	H-22
ABS Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities	B.11.1.1	B-25
ABS Rules for Nondestructive Inspection of Hull Welds	H.5.1.b(2)	H-22
AISC Manual of Steel Construction, Specifications and Codes	H.4.1.1.a	H-7
ANSI/ASQC Q2, Quality Management and Quality System Elements for Laboratories - Guidelines	F.7	F-20
ANSI/NCSL Z540-1, Calibration Laboratories and Measuring and Test Equipment - General Requirements	3.5.4	3-23
ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Unfired Pressure Vessels, and Division 2, Alternative Rules for Pressure Vessels	Table A-2 B.6 B.10.2.1	A-3 B-10 B-22
ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications	3.4.2.b(2)	3-19
ASME B31.1, Power Piping	B.10.1	B-20

REFERENCE	PARAGRAPH	PAGE
ASME PVHO-1, Safety Standard for Pressure Vessels for Human Occupancy	Table A-1 A.5 B.4.1 B.6.3	A-2 A-7 B-9 B-12
ASTM A269, Seamless and Welded Austenitic Stainless Steel Tubing for General Service, Standard Specification for,	Table A-2	A-3
ASTM A312, Seamless and Welded Austenitic Stainless Steel Pipes, Standard Specification for,	Table A-2	A-3
ASTM A336, Alloy Steel Forgings for Pressure and High-Temperature Parts, Standard Specification for,	Table A-2	A-3
ASTM A350, Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components, Standard Specification for,	Table A-1 Table A-2	A-2 A-3
ASTM A352, Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service, Standard Specification for,	Table A-2	A-3
ASTM A494, Castings, Nickel and Nickel Alloy, Standard Specification for	Table A-2	A-3
ASTM A516, Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service, Standard Specification for,	Table A-1	A-2
ASTM A537, Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel, Standard Specification for,	Table A-1	A-2
ASTM B61, Steam or Valve Bronze Castings, Standard Specification for,	Table A-2	A-3

REFERENCE	PARAGRAPH	PAGE
ASTM B148, Aluminum Bronze Sand Castings, Standard Specification for,	Table A-2	A-3
ASTM B150, Aluminum Bronze Rod, Bar, and Shapes, Standard Specification for,	Table A-2	A-3
ASTM B171, Copper-Alloy Plate and Sheet for Pressure Vessels, Condensers, and Heat Exchangers, Standard Specification for,	Table A-2	A-3
ASTM B271, Copper-Base Alloy Centrifugal Castings, Standard Specification for,	Table A-2	A-3
ASTM B369, Copper-Nickel Alloy Castings, Standard Specification for,	Table A-2	A-3
ASTM B466, Seamless Copper-Nickel Pipe and Tube, Standard Specification for,	Table A-2	A-3
ASTM D1292, Odor in Water, Standard Test Methods for,	F.4.4.1.b F.4.4.2.d F.4.4.3.d	F-12 F-13 F-13
ASTM D4174, Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems, Standard Practice for,	H.4.2.4.a	H-19
ASTM D4268, Testing Fiber Ropes, Standard Test Methods for,	H.4.1.1.1.b(3) H.5.1.e(3)	H-8 H-23
ASTM E548, Evaluating Laboratory Competence, General Criteria Used for,	F.7	F-20
ASTM G63, Evaluating Non-metallic Materials for Oxygen Service, Standard Guide for,	B.10.5.e	B-24
ASTM G88, Designing Systems for Oxygen Service, Standard Guide for	B.10.5.b	B-24
ASTM G93, Cleaning Methods for Material and Equipment Used in Oxygen-Enriched Environments, Standard Practice for,	G.2.2 G.4.3	G-1 G-3

REFERENCE	PARAGRAPH	PAGE
ASTM G94, Evaluating Metals for Oxygen Service, Standard Guide for,	B.10.5.d	B-24
BB-A-1034, Air, Compressed for Breathing Purposes	F.3.3.b	F-5
BB-N-411, Nitrogen, Technical	F.3.3.d	F-5
CGA G-4.1, Cleaning Equipment for Oxygen Service	G.2.2 G.4.3	G-1 G-3
CINCLANTFLT/CINCPACFLTINST 4790.3, Joint Fleet Maintenance Manual	I.4	I-2
Cordage Institute Standard Test Method for Fiber Rope	H.4.1.1.1.b(3) H.5.1.e(3)	H-8 H-23
DDS-100-4, Strength of Structural Members	H.4.1.1.a	H-7
DOD-STD-1399-301A, Interface Standard for Shipboard Systems Section 301A Ship Motion and Attitude (Metric)	H.3.1.1.b	H-3
FED-SPEC-RR-W-410D, Wire Rope and Strand	H.4.1.1.1.b(3)	H-8
FED-STD-191, Textile Test Methods	H.4.1.1.1.b(3) H.5.1.e(3)	H-8 H-23
FED-STD-H28, Screw-Thread Standards for Federal Services	B.8.2	B-15
ISO 10012-1, Quality Assurance Requirements for Measuring Equipment - Part 1	3.5.4	3-23
ISO 9001, Model for Quality Assurance in Design, Development, Production, Installation and Servicing	3.5.b	3-21
MIL-B-24480, Bronze, Nickel-Aluminum (UNS No. C95800) Castings for Seawater Service	Table A-2	A-3

REFERENCE	PARAGRAPH	PAGE
MIL-C-15726, Copper-Nickel Alloy, Sheet, Plate, Strip, Bar, Rod, and Wire	Table A-2	A-3
MIL-C-24723, Castings, Nickel-Copper Alloy	Table A-2	A-3
MIL-D-16791, Detergents, General Purpose (Liquid, Nonionic)	G.4.1	G-3
MIL-E-917, Electric Power Equipment, Basic Requirements	Table A-2 A.8.c B.11.6	A-3 A-8 B-28
MIL-F-22606, Flask, Compressed Gas, and End Plugs for Air, Oxygen, and Nitrogen	Table A-2	A-3
MIL-G-27617, Grease, Aircraft and Instrument, Fuel and Oxidizer Resistant	F.4.4.a	F-11
MIL-L-20213, Lithium Hydroxide (LiOH), Technical	Table A-2	A-3
MIL-O-27210, Oxygen, Aviators Breathing, Liquid, Gas	F.3.3.c	F-5
MIL-P-24691, Pipe and Tube, Carbon, Alloy and Stainless Steel, Seamless and Welded, General Specification for,	Table A-2	A-3
MIL-P-27404, Propellant Pressurization Agent Helium	F.3.3.e	F-5
MIL-Q-9858, Quality Program Requirements	3.5.b	3-21
MIL-S-1222, Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws and Nuts	Table A-3	A-4
MIL-S-16216, Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100)	Table A-1	A-2
MIL-S-21952, Steel (HY-80 and HY-100) Bars, Alloy	Table A-1	A-2

REFERENCE	PARAGRAPH	PAGE
MIL-S-22698, Steel Plate, Shapes and Bars, Weldable Ordinary Strength and Higher Strength: Structural	Table A-1	A-2
MIL-S-23008, Steel Castings, Alloy, High Yield Strength (HY-80 and HY-100)	Table A-1	A-2
MIL-S-23009, Steel Forgings, Alloy, High Yield Strength (HY-80 and HY-100)	Table A-1	A-2
MIL-S-24451, Steel Heat Treated Heads, Alloy Structural, High Yield Strength (HY-80 and HY-100)	Table A-1	A-2
MIL-STD-101, Color Code for Pipelines and for Compressed Gas Cylinders	B.10.1	B-20
MIL-STD-419, Cleaning, Protecting, and Testing Piping, Tubing, and Fittings for Hydraulic Power Transmission Equipment	H.4.2.2.1.e H.4.2.4.c	H-16 H-19
MIL-STD-438, Schedule of Piping, Valves, Fittings and Associated Piping Components for Submarine Service	H.4.2.1.b	H-14
MIL-STD-777, Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships	H.4.2.1.b	H-14
MIL-STD-882, System Safety Program Requirements	2.2.2 A.1 H.3.2.1	2-2 A-1 H-6
MIL-STD-889, Dissimilar Metals	B.8.4	B-16
MIL-STD-1246, Product Cleanliness Levels and Contamination Control Program	G.2.1 G.4.3	G-1 G-4
MIL-STD-1310, Shipboard Bonding, Grounding, and other Techniques for Electromagnetic Compatibility and Safety, Standard Practice for,	B.11.5	B-27

REFERENCE	PARAGRAPH	PAGE
MIL-STD-1330, Precision Cleaning and Testing of Shipboard Oxygen, Helium, Helium-Oxygen, Nitrogen, and Hydrogen Systems, Standard Practice for,	3.4.5	3-20
	F.3.4.b	F-6
	F.3.4.d	F-7
	F.5.3.b	F-17
	G.2.1	G-1
	G.4.1	G-3
	G.4.2	G-3
	G.4.3	G-4
	G.5	G-4
	G.6.2	G-5
	J.6.a	J-3
	J.7.a	J-4
	J.8.a	J-5
	J.9.a	J-6
MIL-STD-1472, Human Engineering	B.13	B-30
MIL-STD-1622, Cleaning of Shipboard Compressed Air Systems	3.4.5	3-20
	F.3.4.b	F-6
	F.3.4.d	F-7
	F.5.3.b	F-17
	G.2.1	G-1
	G.4.1	G-3
	G.4.2	G-3
	G.5	G-4
	G.6.2	G-5
MIL-STD-1627, Bending of Pipe or Tube for Ship Piping Systems	3.4.4	3-20
	J.6.g	J-3
MIL-STD-2036, Electronic Equipment Specifications, General Requirements for,	Table A-2	A-3
	A.8.c	A-8
MIL-STD-2193, Hydraulic System Components, Ship	H.4.2.1.b	H-14
MIL-T-1368, Tube and Pipe, Nickel-Copper Alloy, Seamless and Welded	Table A-2	A-3
MIL-T-16420, Tube, Copper-Nickel Alloy, Seamless and Welded (Copper Alloy numbers 715 and 706)	Table A-2	A-3

REFERENCE	PARAGRAPH	PAGE
MIL-V-24439, Valves, Oxygen, Helium and Helium Oxygen Mixture, High Pressure for Gas Services	Table A-2	A-3
NASA JSC 20584, Spacecraft Maximum Allowable Concentration for Airborne Limits	F.6.a	F-20
NAVMEDCOMINST 6260.5, Occupational Noise Control and Hearing Conservation	B.13.1	B-30
NAVSEA 0900-LP-001-7000, Fabrication and Inspection of Brazed Piping Systems	3.4.3	3-19
NAVSEA 0902-018-2010, General Overhaul Specifications for Deep Diving SSBN/SSN Submarines	B.8.2	B-15
NAVSEA 0924-062-0010, Submarine Safety (SUBSAFE) Requirements Manual	1.7 I.4 I.7.a	1-7 I-3 I-5
NAVSEA 0994-LP-001-9110, U.S. Navy Diving Manual; Volume 1, Air Diving	B.10.4 B.13.2 B.14.3.1.c B.16 E.1 E.2 F.3.3.a	B-23 B-31 B-35 B-42 E-1 E-1 F-5
NAVSEA 0994-LP-001-9020, U.S. Navy Diving Manual; Volume 2, Mixed-Gas Diving	B.10.4 B.13.2 B.14.3.1.c B.16 E.1	B-23 B-31 B-35 B-42 E-1
NAVSEA 00C TOPSIDE TECH NOTES, Volume VI, Issue 1, of Oct 95, Diver Life Support System Cleaning	G.2.3 G.4.2	G-2 G-3
NAVSEA 00C4-PI-002, Cleaning Diving System Air Components with Navy Oxygen Cleaner (NOC)	G.2.3 G.4.2	G-1 G-3

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