TOPSIDE TECH NOTES

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Diver Life Support System Cleaning

This Topside Tech Note replaces Topside Tech Note, Diver Life Support System Cleaning, Volume VI, Issue 1 dated October 1995.

Introduction:

One of the most important aspects of maintaining an acceptable Diver Life Support System (DLSS) is ensuring system cleanliness. In general, three types of contaminants must be kept out of the breathing gas system piping. Each of these contaminant types: gaseous, hydrocarbon and particulate, presents a different hazard to the diver and the diving system.

Gaseous contaminants can cause physical harm to the diver due to possible toxicity or flammability. Hydrocarbons, which may be either gaseous or liquid represent a fire hazard and are also toxic to the diver. Particulate contamination can cause premature failure of components (e.g., valves, regulators, etc.), plug small ports blocking gas flow and act as an ignition source in oxygen-rich systems (greater than 25% oxygen by volume).

DLSS cleanliness requirements are taken from MIL-STD-1330 for oxygen systems and MIL-STD-1622 for air systems. MIL-STD-1330 requirements are also used for cleaning Helium, HEOX and NITROX systems. These MIL-Standard requirements must be transformed into step-by-step procedures which are tailored to the specific equipment to be used in the cleaning and analysis process. NAVSEA requires that all commands and commercial activities which perform cleaning of DLSS use only SUPDIVE (NAVSEA 00C3) approved cleaning procedures. Cleaning procedures used at shore-based facilities must be approved by NAVFAC Code 00CE.

CFC-113 (Freon) is no longer authorized for use in cleaning diver life support systems and components, except for bourdon tube gages. Freon is still authorized for use to conduct swipes and as a means to verify hydrocarbon contamination levels. Navy or contractor personnel shall not use Freon for diver life support system cleaning unless specifically authorized by NAVSEA Code 00C3 or NAVFAC Code 00CE.

Maintaining System Cleanliness During Operation and Repairs:

Any time a diver life support system must be entered for repair or maintenance every precaution should be taken to prevent the system from becoming contaminated. Even the possibility that contamination has entered the system may cause time consuming and expensive system cleaning to be performed. This is particularly true for oxygen-rich systems because even minor contamination can result in a fire or explosion.

When removing components from divers air or oxygen systems for repair or replacement several basic rules should be followed:

WARNING

Always bleed all pressure from the system before commencing any work!

WARNING

Follow all precautions in NSTM Chapter 550, Section 6 when working with oxygen.

CAUTION

Anodized aluminum may not be compatible with the cleaning solutions and procedures described below. Contact NAVSEA 00C3 for recommended procedures.

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From the Office of:
Director of Ocean Engineering
Supervisor of Salvage and Diving

Always clean your hands and tools prior to removing a component. All tools used shall be free of oil, grease and particulates. It is recommended that tools used for repairs on DLSS be kept separate and locked up. The component to be removed and the adjacent external piping surfaces must be thoroughly cleaned using a nylon bristle brush and an approved cleaning agent. Navy Oxygen Cleaner (NOC) solution with water is recommended for external precleaning of air and oxygen system components because it is compatible with most metals and rubbers. Non-Ionic Detergent (NID) and Tri-Sodium Phosphate (TSP) solution may also be used as precleaners. Due to material incompatibility, TSP shall not be used on aluminum or copper components and TSP and NOC shall not be used on components potted with epoxy compounds. The solution strengths for these precleaning agents are given in the *Precleaning and Cleaning Agents* subsection on pages 3 and 4.

It is strongly recommended that commands verify those cleaning agents which may be considered hazardous material with local authorities, and observe local usage and disposal regulations.

After precleaning, the component and piping must be immediately and thoroughly rinsed off with fresh water and dried. Do not allow the precleaner solution to dry prior to rinsing. Unless immediately rinsed off, precleaners will leave a residue on the component that is difficult to remove.

Prior to removing the component, loosen all connections to finger tight. Ensure that there are clean blank fittings or a layer of clean polyethylene plastic and tape to place over the piping connections immediately after the component is removed. It is recommended that two layers of polyethylene sheeting be used if there is a chance that the single layer might be punctured. Do not use wood or unthreaded plastic plugs which may shed and contaminate the piping. If the system will remain open for more than 24 hours, it is recommended that hard blank fittings be used, rather than polyethylene plastic sheeting, to seal the piping connections. Also, ensure that there is a clean polyethylene bag large enough to hold the entire removed component or clean blank fittings or clean polyethylene plastic to tape around the component ends.

Always try to work out of the weather. If possible move portable systems into a clean area shielded from the wind and debris. If this is not possible, use large clear polyethylene sheeting or a glove bag wrapped and taped around the piping, approximately one foot from the component connections to form a containment. Tape the plastic containment shut, leaving just enough room around the sheeting to use your hands and tools to remove the component.

Always clean and repair the removed component in a space meeting the criteria described in the *Clean Work Area* subsection on page 3. Both precleaning and final cleaning of internal component surfaces must be accomplished in the clean area. The command should have such an area designated to work on DLSS components.

Completely disassemble component and conduct precleaning and final component cleaning per a NAVSEA 00C approved procedure.

NOTE

Forwarded with this Tech Note is NAVSEA-00C4-PI-002, Cleaning Diving System Air Components with NOC. This approved procedure may be used to clean air system valves and fittings.

If installing a new component, its cleanliness must be verified prior to installation. Components obtained from the manufacturer as "OXYGEN CLEAN" may be used in air systems only, provided that NAVSEA has reviewed and concurred with the manufacturer's procedures. Most component manufacturers' oxygen cleaning procedures are not acceptable for use in divers oxygen systems because they do not meet the requirements of MIL-STD-1330.

Questions concerning the acceptability of a commercial oxygen cleaning procedure should be addressed to NAVSEA, Code 00C3. All repair parts must be cleaned prior to installation in the component being repaired. If these repair parts are to be cleaned and stored for later use they must be placed in double layers of polyethylene bags or plastic wrap. It is recommended that the plastic be heat sealed to prevent inadvertent opening. If both layers of plastic are found open at any time the part must be recleaned. Where commands store oxygen and air cleaned parts, a tag must be placed between the two plastic layers identifying that the component has been cleaned, and to what level it has been cleaned (e.g., OXYGEN CLEANED PER MIL-STD-1330, DIVERS AIR CLEANED TO MIL-STD-1622, etc.).

System cleanliness must be maintained when reinstalling components. Always repair, clean and reinstall components as soon as possible.

Equipment Required for Cleaning DLSS Components:

There is some basic equipment for cleaning DLSS components which should be used whenever components are being repaired:

Ultrasonic Sink – Tank dimensions should be large enough to allow the

largest single component in DLSS to be submerged. The transducer shall have a minimum power rating of four watts per square inch, a frequency greater than 25 kH and capable of heating solution to 180°F.

Clean Work Area – For cleaning oxygen system components, the work environment must be a clean area per MIL-STD-1330. A portable laminar flow station, such as a Class 10 Model 250T available from International Portland Corporation, (503) 648-1504 or equivalent is recommended.

For cleaning air system components, the work area must have a cleanliness level at least equivalent to that of a clean office environment and must not open directly to the weather or where industrial work may be taking place. The overhead must be free of loose debris and dust, or must be covered with polyethylene sheeting.

Protective Clothing – Protective clothing including rubber gloves, apron and full face shield are required when working with most cleaning agents. The vendor Material Safety Data Sheets (MSDS) should be consulted before working with cleaning agents. Lint-free gloves are required when handling oxygen system components that have been cleaned.

Ultraviolet Light – A handheld UV light with a wavelength of 3,600 to 3,900 angstroms is required.

White Light Source – A handheld unit of at least 100 candlepower. An ordinary D-cell flashlight with xenon bulb is acceptable. The flashlight must be held within 18 inches of the item being examined.

White Sampling Dish Or Clear Sample Bottle – To be used for inspecting cleaning solution or rinse water for particulates per MIL-STD-1330C(SH), paragraph 4.2.3.1. Clear 1 liter sample bottles are also needed to take samples for hydrocarbon analysis of the cleaning solution in the ultrasonic sink.

Component Drying Source – Diver's air or a heat gun may be used to dry air system components. Filtered, dry, oil-free nitrogen per BB-N-411, Type I, Class I, Grade A (25 micron absolute filter element) should be used to dry oxygen components.

Pipe Capping/Bagging Material – Polyethylene sheeting per MIL-B-22191, TYPE 1 may be used for covering open ended pipe or making containments to remove components. If cleaned components are to be stored prior to installation, this type of material can be purchased as heat sealable bagging and used in a double enclosure (double bagged) with a tag between the first and second bag to indicate whether the component is oxygen clean or divers air clean. Clean piping caps or blanks should be used to prevent the piping system from being contaminated. The caps/blanks must be non-shedding and non-rusting and cleaned to the same level as the system.

DLSS Tools – A set of clean tools for repairing DLSS components should be kept separately from other tools. It is strongly recommended that some non-sparking tools be included for removing oxygen components from the system. Never use vicegrips, pliers or similar tools which will gall the components and create metal particulate. Always verify that the tools are clean by using a black light and wiping with a lintfree rag, then inspecting the rag for grease and dirt.

Lint-Free Rags – Clean white lint-free filter cloth. These rags must be disposed of whenever there is any sign of shedding or lint. Whenever they become soiled they shall be washed prior to their next use.

Filtered Water – A supply of filtered water for rinsing components and diluting cleaning agents. U.S. Navy Grade B water per MIL-STD-1622A, filtered to 25 microns is highly preferred as a cleaning agent diluent and rinse water. If Grade B water is not available, fresh, filtered tap water may be substituted for use in cleaning air system components only. The use of tap water can leave hard deposits on the components. To lessen the potential of hard deposit formation; minimize the cleaning cycle duration, do not reuse the cleaning solution and blow dry the cleaned and rinsed components with filtered, dry, oil-free nitrogen or diver's air.

NOTE

Thorougly rinse components immediately after precleaning and cleaning. Otherwise, a residue will remain on the component and require additional final cleaning cycles.

Precleaning and Cleaning Agents – The recommended cleaning agent for oxygen system components is NOC [NSNs: 5 gal. - 6850-01-389-3859; 55 gal. - 6850-01-389-3880]. This is also the preferred cleaning agent for divers air system components. NOC can also be used for precleaning. NOC is superior to TSP and is environmentally safe. NOC should be used 1:1 with filtered water (preferably Grade B). The solution temperature should be 140°F - 160°F.

NID per MIL-D-196791, Type I can be used to externally preclean both air and oxygen systems. NID can be used as a final cleaner only for air system component softgoods (e.g. o-rings, valve seats, and captured gaskets), recompression chamber surfaces, and the surfaces of some UBAs (per the specific technical manual).When using NID, the ratio is .5 oz. NID to 1 gallon warm filtered water (preferably Grade B).

NID should only be used at temperatures less than 120°F, as it will come out of solution at higher temperatures.

TSP may be used as a precleaning and cleaning solution for both air and oxygen components. If using TSP, the maximum concentration should be 6.4oz. TSP to 1 gallon of hot filtered Grade B water. TSP must be used at temperatures between 160°F and 180°F. If temperature of the solution drops below 140°F, the TSP will come out of solution and may become lodged in the component being cleaned.

NOC and TSP are incompatible with components potted in epoxy. TSP is also incompatible with Aluminum and copper. These agents shall not be used with these materials. Do not mix any cleaning solution to concentrations greater than those recommended above.

Basic Piping Component Cleaning Guidelines:

NAVSEA letters Ser 03Y2A/081, dated 24 March 1994 and Ser 03Y2A/122, dated 7 April 1995 provided a report and supplement report, respectively, on new standard Navy oxygen cleaning processes for cleaning oxygen system components with NOC. We recommend that these processes be used for cleaning DLSS (both air and oxygen) components. NAVSEA Process Instruction NAVSEA-00C4-PI-002 has been developed, based on these reports, to provide diving commands with a standard instruction to clean components for diving air systems. Diving commands are encouraged to use this Process Instruction. Those commands desiring to write their own air system cleaning instruction must obtain approval for their use from NAVSEA (Code 00C3)

Only qualified Navy personnel who have been trained as oxygen clean room technicians are authorized to clean and perform hydrocarbon analysis on oxygen system components.

Cleaning of Recompression Chamber Interior Guidelines:

Normal housekeeping and cleaning of recompression chambers is accomplished in accordance with U.S. Navy PMS MRC 5921/001 M-3R.

Whenever industrial work is performed inside a recompression chamber, a more thorough cleaning is required. This involves vacuuming all loose debris, removal and cleaning of the deck plates and a complete washdown of the interior surfaces with NOC or NID solution. All washed surfaces must be thoroughly rinsed and dried.

If the recompression chamber interior is to be painted, NAVSEA Process Instruction NAVSEA-00C3-PI-001, Recompression Chamber Interior Painting and Sampling should be used to prepare and paint the chamber, and conduct a subsequent gas analysis.

WARNING

Commands shall not repaint or touch up interior surfaces of TRCS without prior written approval from NAVSEA 00C3.

Analyzing Component Cleanliness After Cleaning:

The real difference in the way that oxygen and divers air systems are treated comes in the requirements to verify that the components are clean. The potential for explosion and fire in an oxygen system, which is contaminated with hydrocarbons, is very real. Therefore, a quantitative analysis of hydrocarbon contaminant levels in cleaned oxygen system components is required.

Divers air components which have been cleaned to the standards of the NAVSEA oxygen cleaning reports discussed in the *Basic Piping Component Cleaning Guidelines* section may only require qualitative analysis.

Oxygen Systems – All oxygen system components and repair parts must be analyzed for contaminants after they are cleaned. At this time, the most common approved method of hydrocarbon analysis involves the use of an infrared spectrophotometer and Freon. As previously stated, only trained qualified personnel shall be permitted to clean and conduct analysis of oxygen system components. The standard Navy oxygen cleaning processes, discussed in the *Basic Piping Component Cleaning Guidelines* section should be used to conduct the required analysis for oxygen system components. Lint-free gloves are required when handling oxygen system components that have been cleaned. The inspection procedure for particulate contaminants is described in both the NAVSEA oxygen cleaning reports and MIL-STD-1330.

Air Systems – Inspection for hydrocarbon contamination of newly cleaned air system components is very basic, provided either NAVSEA-00C4-PI-002 or a similar NAVSEA-approved cleaning process is used to clean the component. As prerequisites to cleaning, the component must have been thoroughly precleaned and the precleaning agent rinsed off with heated (approx. 110°F) filtered water (preferably Grade B). The cleaning solution in the ultrasonic tank must be inspected for possible hydrocarbon contamination before each use and after cleaning each component. Inspection of the NOC for hydrocarbon contamination can be done by obtaining a sample of NOC from the ultrasonic tank in a

clear bottle and using a bright white light to inspect for telltale oil sheen or cloudiness in the NOC. Also perform a shake test to detect soluble hydrocarbons by vigorously shaking the sample bottle for 15 seconds. Hydrocarbons are present if bubbles remain after 5 minutes. If hydrocarbons are detected the solution shall be replaced and the components recleaned. NOC should not be used more than five times between solution changes unless a quantitative hydrocarbon analysis of the solution is performed.

Thoroughly, rinse the component with heated (approx. 110°F), filtered, water (preferably Grade B) to remove the cleaning solution. The removal of the cleaning solution can be verified by testing the pH level of a small amount of rinse water passed over/through the component collected in a jar or test tube. A pH level of less than eight indicates that the cleaning solution has been removed.

Visually inspect the rinse water for particulates with a 100 candlepower white light (an ordinary D-cell flashlight with a xenon bulb may be used,) held no more than 18 inches from the solution. The sample to be inspected must be in either a clean white dish or a clear clean jar. The particulate level is acceptable if no particles are visible.

Dry the component with compressed filtered divers air until all traces of moisture are gone. Alternatively, a heated vacuum oven may also be used to dry metallic components without software (seals, o-rings, etc.). Software may be dried with clean lint-free rags.

Visually inspect all accessible internal component surfaces with a 100 candlepower white light (an ordinary D-cell flashlight with a xenon bulb, held no more than 18 inches from the component, may be used) for the telltale sheen which indicates the presence of hydrocarbons.

Visually inspect all internal component surfaces with a black light to verify no hydrocarbons are present.

If the above inspections do not reveal hydrocarbon or particulate contamination or cleaning agent residue, the component may be reassembled and installed.

DLSS Software – Software should be cleaned using a clean lint-free rag saturated with NID solution, and thoroughly rinsed and dried with a clean, dry lint-free rag.

O-ring grease must be applied very sparingly (a light sheen) or it will extrude into the system where it will trap particulates and plug small ports, blocking gas flow.

WARNING

Do NOT use chlorofluorocarbon greases (e.g., Halocarbon grease and Fluorolube) on aluminum components.

NOTE

Nontoxic silicon grease is recommended for use in air system components. Lubricants listed in Table 12 of NSTM Chapter 262 may also be used for air systems.

NOTE

Use only lubricants listed in Table 12 of NSTM, Chapter 262 when installing o-rings or other software in oxygen systems.

Component Cleaning Documentation Requirements:

All cleaning of divers life support gas components must be documented and be available to the SCA for review. The information required to be documented is as follows:

Approved cleaning procedure.

Item(s) cleaned – part number, quantity and system type (air, oxygen, exhaust, etc.).

Date item cleaned.

Precleaning and cleaning agents used.

Verification of cleaning agent removal.

Hydrocarbon analysis – method used and results.

Particulate analysis – method used and results.

Software replacement – List all software (i.e., o-rings, seals, etc.), mfg P/N, cleaning agent used, cleaning analysis method used.

Signature of person(s) performing above operations.

In addition to the required cleaning operations, testing for adequate hydrostatic strength when pressure retaining parts are replaced and internal gas tightness (i.e., valve seat tightness) should be conducted prior to reinstalling the removed component. Hydrostatic strength testing should be accomplished prior to cleaning to prevent possible contamination of already clean parts. NAVSEA 00C is presently developing Process Instruction NAVSEA-00C4-PI-003 to provide procedures for hydrostatic testing.

Contracting for Cleaning Services:

Past experience has shown that care and attention to detail are required when a command contracts for outside cleaning services. The diving command must fully understand the scope of the work to be performed and ensure that the contractor is using only NAVSEA-approved cleaning procedures. Commands should ensure that they have the right to conduct periodic inspections of the contractor's cleaning

facility to verify that those procedures are being followed. In cases where the command is contracting for in-place piping system flushing, command personnel should become knowledgeable in the equipment and methodology used to perform pipe flushing.

Some items to spot check for are:

- Is the contractor using a NAVSEA-approved procedure?
- Does contractor have cleanliness and hydrostatic test (where required) verification for all new or repaired components to be installed after flushing is complete?
- Does the contractor have a flushing diagram which specifies flushing boundaries, direction of flow, inlet and outlet points, flow rate, where flush plugs are installed in valves, which components have been removed and where jumpers and blanks have been installed?
- Has the contractor verified that software has been removed from components to be flushed or will be replaced after flushing is complete?

For further information on cleaning divers life support system components contact:

NAVSEASYSCOM (Code 00C4) for certification issues: DSN 326-0927 or commercial (202) 781-0927.

NAVSEASYSCOM (Code 00C3) for technical issues: DSN 326-0934 or commercial (202) 781-0934.