The International Marine Contractors Association

Cleaning for Oxygen Service

Setting Up Facilities and Procedures

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There are also four regional sections which facilitate work on issues affecting members in their local geographic area – Americas Deepwater, Asia-Pacific, Europe & Africa and Middle East & India.

IMCA D 031

This update of the earlier AODC document was prepared by IMCA, under the direction of its Diving Division Management Committee, incorporating information kindly provided by Divex Ltd.
This document supersedes AODC 029, which is now withdrawn.

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Cleaning for Oxygen Service

1 BACKGROUND

Due to the combustion risk from hydrocarbons, all pipework, fittings, valves and other equipment which might be used in oxygen enriched atmospheres should be scrupulously cleaned.

IMCA issued guidance note AODC 029 - *Oxygen cleaning* – in 1984, which provided guidance on the use of two basic procedures for such work, covering volatile solvents and aqueous based detergents. However, the Montreal Protocol has prevented the use of volatile (chlorinated) solvents, due to their ozone depleting potential and chlorofluorocarbon (CFC) base. This guidance note therefore supersedes the previous AODC publication.

To help develop revised IMCA guidance, Divex Ltd produced a discussion document on oxygen cleaning. This guidance note draws on much of the valuable information provided in that document.

2 OVERVIEW

There are many theories as to how to clean for oxygen service – some scientifically based and others based on experience. Most procedures used within the diving industry are a mixture of both. Often, a number of procedures for various cleaning requirements are developed, one of which might detail how to clean for breathing air service. Cleaning for breathing air service is often confused with the requirement to clean for oxygen service. The requirement to clean for oxygen service normally requires a higher cleaning specification than that for breathing air. It should also be noted that breathing air and oxygen-compatible air, sometimes referred to as 'clean air', are not the same and each has its own purity specification.

Cleaning methods vary and most diving contractors will have in place company procedures. This document attempts to set out some of the areas that should be considered when developing oxygen cleaning procedures. The aim of this document is to provide up-to-date information and guidance to enable contractors to develop and operate a cleaning process that produces equipment that is safe for oxygen service.

3 SCOPE

This guidance note covers a number of areas within the cleaning-for-oxygen-service cycle as follows:

- Where and in what environment the equipment is to be used;
- Design and compatibility of materials;
- Cleaning new or used equipment;
- Environment in which cleaning takes place;
- Cleaning agents to be used;
- Method of cleaning;
- Testing for cleanliness;
- Packing and marking;
- Re-cleaning plant for oxygen service (on-site/offshore).

4 CLEANING FOR OXYGEN SERVICE

4.1 Where and In What Oxygen Environment the Equipment is to be Used

A number of sources suggest the percentage oxygen above which equipment requires cleaning for oxygen service. The percentage, pressure and flow of oxygen, along with the material being used, will determine the need for oxygen cleanliness. For the purposes of this document, any equipment being used for oxygen percentages greater than 25% by volume should be cleaned for oxygen service.

There is always, somewhere within a system that mixes, blends or utilises oxygen-enriched air, the potential for high level percentages of oxygen to enter or come into contact with non oxygen service components. Hazard identification and risk assessment of such systems should take into account component failures. Also, the use of oxygen compatible components and cleaning to oxygen service standards in risk areas could prevent an incident.

Another issue to be considered is the way in which equipment to be used with oxygen enriched gas is assembled. Normally, the gas path will be considered in great detail. However, the materials that could see oxygen if a leakage occurs can be overlooked. If maintenance or assembly is undertaken, it is possible for contamination to be spread to clean areas if the outer surfaces of the components are not cleaned to the same standard.

Where systems which have been cleaned for oxygen service are then used in air service, whether using pre-mixed or compressor-generated air, consideration should be given to the likely level of cleanliness and the requirement for cleaning prior to re-use in oxygen service.

4.2 Design and Compatibility of Materials

Most organisations involved in the design and selection of materials used in oxygen systems will have lists of oxygen-compatible materials. They will include preferred metals, soft seals and oxygen-compatible lubricants.

There are methods of approving materials for oxygen compatibility. The most common is known as a 'bomb test' (Ref. 1). These tests are carried out to determine the compatibility of a material for use in oxygen-enriched or pure oxygen atmospheres at pre-designated pressures. A vast amount of information has been gathered on the compatibility of materials. Where compatibility is in any doubt, advice should be sought on whether tests for compliance have been carried out and whether the information is available.

Choosing materials when designing systems needs careful consideration. The correct design of a system is important in reducing the risk of an oxygen fire. Systems should be designed such that the size of the pipework and all components, including changes in the size of pipework, does not cause high gas velocities.

An area that is often overlooked is debris within the system after assembly. This could be the result poor quality build such as metal particles or swarf left

on the pipework and excess oxygen-compatible sealing tape on threaded joints.

Adiabatic compression is described as occurring *when oxygen under high pressure is released quickly into a low pressure system*. The gas flow can reach the speed of sound and, if it encounters an obstruction, the temperature can rise high enough to initiate combustion of flammable material. Adiabatic compression can be avoided, for example by reducing the oxygen pressure at source, by installing a pressure controller directly on the outlet valve of the oxygen bank and/or use of needle valves instead of quarter-turn valves on all oxygen circuits. Education and training of personnel on the risks associated with adiabatic compression is important.

4.3 Cleaning New or Used Equipment

Consideration must be given to the equipment to be cleaned. Equipment used offshore can see the harshest of environments and can be returned to the shore in a very bad state. This may include salt sea spray or marine growth on the outside of equipment or hydrocarbon build-up on the inside of systems. This equipment should first be pre-cleaned by a suitable method such as steam cleaning or by using more aggressive cleaning agents. This should be carried out away from the clean room to prevent contamination.

The cleaning of new materials such as soft seals and machined parts can normally take place immediately within the oxygen cleaning area.

4.4 Environment in which Cleaning Takes Place – Onshore Situation

There are standards (such as Ref. 3) available which define a 'clean room'. These rooms are normally under a small positive pressure and air is filtered to defined standards. It is not normally necessary to provide such expensive facilities to undertake oxygen cleaning. A vast proportion of oxygen cleaning can be undertaken in a controlled area. A controlled area can be defined as a*ny working space that is not a 'clean room', but where cleanliness control procedures create an environment free of oil, grease and dust* (Ref. 4). The rooms should be easily cleaned on a regular basis and be constructed of materials that do not collect dust, etc. The biggest problem in these areas tends to be when breeze block walls are painted with masonry paint or concrete floors are left badly treated. Dust build-up can create a situation which makes cleaning even more difficult. Sheeting the walls with suitable plastic boarding and covering the floor with easy clean tiles can remedy these problems. The corners of the rooms can have bevelled edgings similar to those used in hospitals. Stainless steel benches are best for clean environments.

It would obviously be an advantage if the controlled area were free of pollution from the likes of forklift exhaust fumes or welding fumes from the fabrication shop. Careful consideration should be given to exhaust and air intake in cleaning areas. Personnel carrying out cleaning procedures should wear clean overalls and lint-free gloves when handling finished clean parts. The cleaning area should be checked regularly for contaminants.

4.5 Cleaning Agents to be Used

This is one of the biggest problems encountered when determining oxygen cleaning procedures. The best cleaning agent to use will depend on the type of materials to be cleaned. As noted earlier, although chlorinated cleaning solvents are no longer considered suitable, there are a number of non-chlorinated cleaning agents commonly used today which are suitable. Advice on suitable cleaning agents should be available from diving equipment suppliers.

In general, suitable substances tend to be naturally-based biodegradable biological cleaning agents. However, the manufacturer should be consulted before use to ensure that the cleaning agent is oxygen-compatible, environmental friendly, non-toxic and non-flammable.

4.6 Method of Cleaning

Cleaning procedures should be well documented for all the various aspects of cleaning that can be undertaken. Equipment to be cleaned for oxygen service should be stripped to component level prior to cleaning, then reassembled once suitably cleaned. As detailed in section 4.3, pre-cleaning of equipment that is heavily contaminated should take place away from the cleaning area.

The soft goods should be separated from the metal components. It is often the case that soft seals, such as 'o' rings, are replaced with new parts. However, not all non-metallic components will be replaced. The cleaning agent used will depend on the component being cleaned. The manufacturer/supplier should be able to provide details of the suitability of the agent for cleaning the component and procedures for its use.

A dryer is likely to be the best method of drying the components. However, if components are blown dry or left to air-dry, a residue may be left at some point.

4.7 Testing for Cleanliness

There are a number of methods used to test for oxygen cleanliness. One of the most common is visual inspection using ultraviolet (UV) light. Most tests are limited to determining the presence of a contaminant, not the absence.

Cleaned equipment and components can be tested using a long wave UV light (3600-3900 Angstrom) for oxygen cleanliness. Samples of final cleaning solutions should be allowed to evaporate and then inspected when under the UV light. Hydrocarbons will fluoresce under the UV light. However, most synthetic oils and greases do not fluoresce, while some non-metallic substrates may, which could lead to false results.

Other tests for oxygen cleanliness may require specialised equipment and/or training.

4.8 Packing and Marking

Packing should not contaminate the cleaned component. It is important that all packing materials are free of contaminants and should be inspected prior to use. It is common practice to use lay flat polyethylene tubing, which can be heat sealed to give an airtight barrier. The packing is best if a double barrier of tubing is used. Damaged packing will result in the components needing to be re-cleaned. Components that are to be assembled at a later date should also be packed using this method, as cleaned components must not be left around the assembly area. Hoses and pipework should be blanked at the ends. The blanks must also be cleaned prior to use to prevent contamination.

All cleaned components should be clearly marked "CLEANED FOR OXYGEN SERVICE". Any components not marked should be cleaned prior to use.

5 RE-CLEANING PLANT FOR OXYGEN SERVICE (ON SITE)

5.1 Can the Unit be Cleaned On Site?

Before going ahead with the cleaning of a piece of equipment for oxygen service on site, the following should be considered:

- How dirty is the surrounding environment?
- Can the cleaned parts be guaranteed to remain clean until such time as the system is fully sealed and re-commissioned?
- After addressing any issues raised by investigating 5.4, is it cost effective to do the cleaning on site?

5.2 Design and Compatibility of Materials

- If the unit is being re-certified, are there any aspects to which any certifying authority rules or regulations apply that may have changed since the unit was originally certified? If so, do they need addressing?

5.3 Cleaning the Equipment

- Which parts can be flushed?
- Do fittings and equipment need to be removed and cleaned separately?
- Does equipment (such as regulators, etc.) need to be stripped down and cleaned at component part level? If so, reassemble using appropriate greases, etc.

5.4 Environment in which Cleaning Takes Place

- Can the environment be cleaned sufficiently to conform to the required standard?
- Can the environment be covered with suitable materials to conform to required standards?
- Do the atmospheric conditions require control within the area of cleaning?

- Are there any airborne contaminants in the cleaning area?
- What precautions are required to maintain cleanliness until completion?

5.5 Cleaning Agents to be Used

As per section 4.5, with the addition of clean hot water

5.6 Method of Cleaning

- Are any of the parts corroded or badly marked?
- Do any of the parts require aggressive cleaning prior to measurable oxygen service cleaning?
- Do any parts of the system require flushing with clean hot water to remove any large foreign bodies and dislodge any heavy dirt prior to measurable oxygen service cleaning?
- Can hot water flushing be dumped overboard in maritime environments?

5.7 Testing for Cleanliness

As per section 4.7

5.8 Packing and Marking

As per section 4.8

6 REFERENCES

1 British Standard BS 4N 100-2:1999 – *Aircraft Oxygen Systems & Equipment: Tests for the Compatibility of Materials in the Presence of Oxygen*

2 Technical Bulletin No 5 – *Oxygen Systems*. Swagelock Companies (August 1993)

3 British Standard BS 5295 Part 1 – *Environmental Cleanliness in Enclosed Spaces. Specification for clean rooms and clean air devices*

4 DGUW (N) PUB No 84155 as published by the UK Ministry of Defence