Diving Equipment in Oxygen Service

Guidance for Cleaning, Inspection and Labelling of Items for Use as Part of a Diving System

SCUBA INDUSTRIES TRADE ASSOCIATION

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Contents

The Scuba Industries Trade Association (SITA) needs to ensure a level of uniformity in procedures that affect the United Kingdom diving industry. As part of this need, SITA publishes documents, guidelines and procedures for use as methods of operation and as references for the creation of operational procedures.

Guidelines and memoranda published by the European Industrial Gases Association, Health & Safety Executive and National Aeronautics and Space Administration have also been consulted in the drafting of this document.

1 Scope

This document provides guidance for placing scuba diving equipment into “Oxygen Service” where components or a system of components is exposed to oxygen or oxygen enriched air with an oxygen content greater than 21%.

2 Reference documents

The following reference documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document, including any amendments applies.

BS 5N 100-7, Aircraft oxygen systems and equipment - Part 7: Guide to cleaning labelling and packaging

BS 5295-0, Environmental cleanliness in enclosed spaces - Part 0: General introduction, terms and definitions for clean rooms and clean air devices

The Control of Substances Hazardous to Health Regulations 2002 SI 2002/2677 (as amended) The Stationery Office ISBN 0 11 042919

Control of substances hazardous to health (Fifth edition). The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved Code of Practice and guidance L5 (Fifth edition) HSE Books 2005 ISBN 0 7176 2981 3

EH40/2005 Workplace exposure limits: Containing the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations 2002 (as amended) Environmental Hygiene Guidance Note EH40 HSE Books 2005 ISBN 0 7176 2977

3 Terms and definitions

3.1

Component
An individual part of a unit of two or more assembled parts which have been designed to allow disassembly for servicing

3.2

Contaminant
Any foreign or unwanted substance that can have deleterious effects on the operation, life, safety or reliability of an oxygen service system

A list of typical contaminants includes but is not limited to:

a) Hydrocarbon greases, brazing fluxes and oils

b) Thread lubricants

c) Water

d) Dirt & hair

e) Blast cleaning materials

f) Lint

g) Filings, sward, scales & powders

h) Rust particles and oxide films

I) paints & varnishes

j) Cleaning solvents

3.3

Oxygen clean
Refers to a component or item to be used in an oxygen system, which has been specially cleaned to remove and/or substantially reduce the concentrations of contaminants to minimize the risks of fire and explosions occurring

3.4

Oxygen compatible air
Air suitable for blending with oxygen and free of contaminants listed in 3.2

3.5

Oxygen enriched air
An alternative term used for Nitrox when oxygen has been added to air

3.6

Oxygen compatible
Refers to the material and configuration of the component and its suitability for use within an oxygen system. The material will not react with oxygen at the operational pressures and temperatures specified for the system

3.7

Oxygen service
Refers to an item, which is oxygen compatible and oxygen clean. Oxygen compatible + oxygen clean = oxygen service

3.8

Oxygen system
Combination of items in oxygen service making up an operational system such as a Nitrox SCUBA set or Rebreather

3.9

Nitrox
Gas comprising a specified mixture of oxygen and nitrogen, capable of supporting human life under appropriate diving conditions

NOTE: This includes manufactured gas mixtures made up from combinations of pure oxygen and pure nitrogen, with or without compressed air.

4 General description

4.1 Work area

It is essential to maintain a clean work area ensuring that cleaned oxygen service components remain clean until packed and sealed or reassembled. Ideally the work area should be a designated clean room or separate clean area in accordance with BS 5295 with facilities to handle any cleaned component without risk of re-contamination. Doors from a workroom should not open to the external environment or into an area of high levels of airborne contaminants. The area should also be remote from contaminants such as oils or greases. Disassembly/assembly benches should be kept clean and free from oil and grease. A suitable, replaceable covering should be provided for the bench. The air inside the room should be filtered to remove over 100 µm size particles and ventilated to reduce exposure to solvent fumes from certain cleaning operations.

Reference shall be made to Control of Substances Hazardous to Health (COSHH) documentation to ensure workplace exposure limits are not exceeded.

Smoking, eating and drinking within the work area should not be permitted in an oxygen clean work area.

If a workroom or area cannot be designated as a clean room, then a localized clean area for cleaning and assembly of small components, such as regulators or cylinder valves, may be achieved using a laminar flow bench or enclosed laminar flow cabinet.

Technicians undertaking cleaning operations should have clean hands. Barrier creams, moisturising or cosmetic creams of any description should not be applied to the hands or face at any time immediately prior to or whilst in the designated clean area. Clean room gloves should be made available to minimize contamination after cleaning. Outdoor shoes are to be covered to prevent the introduction of contamination into the work area. Lint producing clothes should be prohibited in the work area.

4.2 Disassembly of systems

If construction permits, assembled systems should be fully disassembled for cleaning of individual components of oxygen enriched air or oxygen systems.

Cleaning an assembled system by flushing, can deposit or concentrate contaminants in blind holes or recesses. Non-volatile cleaning agents can remain trapped and may react later with oxygen. Cleaning solutions may degrade non-metallic materials inside assemblies or may cause corrosion of metallic items.

Where construction does not permit disassembly it may be more prudent and economic to replace the complete item.

4.3 Bought-in items

Bought-in items such as valves, regulators etc. should preferably be cleaned by the original manufacturer prior to assembly and test. They should be supplied suitably packaged to prevent re-contamination and labelled as oxygen clean. The purchaser should specify if certificates of cleanliness are to be supplied with the items, and should assess the suppliers cleaning processes and written procedures as part of their own procedural documentation.

Where bought-in items have to be cleaned by the purchaser, they should, if possible, be disassembled following the manufacturer's instructions, inspected for damage, cleaned and tested for cleanliness, reassembled, and finally tested for correct function.

5 Cleaning methods

5.1 Mechanical cleaning

Mechanical cleaning takes the form of chipping, scraping, flailing, grinding, wire brushing or blast cleaning with sand or glass beads. This is often used as a first stage method for cleaning heavy contamination from the surface, but it can leave particles that must be removed at a later stage. Mechanical cleaning may not remove all oils and greases and can be enhanced utilising alkaline solutions.

Any mechanical cleaning method will create contaminants which are both hazardous to health and damaging to clean room environments. Suitable protective clothing and containment methods, such as blast cleaning cabinets, shall be employed to reduce the risk to persons and property.

5.1.1 Wire brushing

Wire brushes manufactured from non-ferrous wire are recommended. Any wire brush used on a carbon steel surface shall not be used on an aluminium alloy or stainless steel surface.

5.1.2 Blast cleaning

Blast cleaning methods can be used using dry, oil-free compressed air, nitrogen or high pressure water as the propellant. The blast cleaning method is less suitable on aluminium alloys due to the embedding of grit or uneven metal loss.

5.1.3 Tumbling

Tumbling can be described as a mechanical cleaning method that uses a quantity of hard abrasive material placed in a cavity to clean the internal surfaces. The cavity and the abrasive are energized so as to impart relative motion between the abrasive material and the cavity. This method can also be used to clean the outside surfaces of small components placed inside the container with or without the abrasive material.

5.2 Aqueous chemical cleaning

5.2.1 Acid cleaning

Acid cleaning uses solutions with a pH value <7.0 and is not normally used to remove oils or greases. These contaminants are easier to remove with Alkaline or solvent cleaners. Acid cleaning is often employed to remove build-up of debris such as verdigris on copper or brass alloy. An agitator such as an ultrasonic cleaner is generally used with small items to speed the cleaning process.

Any acid has to be used in the correct manner on materials and any material/acid mismatch can cause lasting damage. Further information should be sought from manufacturers as to what is safe and unsafe.

Acids must be removed from the component after cleaning by rinsing with flowing water; Hot water will aid the drying process. Some acids will require an inhibitor to reduce any chemical reaction prior to rinsing with water.

Strict adherence to COSHH is required regarding the handling and environmental disposal of acids. Supplier information must form part of your material handling documentation on file. Industrial or household sewer systems are not to be used for disposal.

5.2.2 Alkaline cleaning

Alkaline cleaning uses solutions with a pH value >7.0 and is good for removing greases, oils and cutting fluids. Alkaline solutions are good to use prior to use of an acid solution for pickling, brightening or etching.

This cleaning method is normally carried out as a chemical cleaning process to remove oils and greases, with a caustic solution at elevated temperature, in the range of 38°C to 82°C dependent upon solution concentration.

Caustic solutions are made up from powders, crystals or concentrated solutions. All are water soluble. Other chemicals with functions such as water softening, corrosion inhibition and wetting are often added.

The manufacturer's specification for application of the cleaning agent shall be strictly observed. After cleaning, all components shall be thoroughly rinsed using oil-free water, preferably hot to aid drying, unless otherwise specified by the supplier of the chemical materials. This is particularly important for copper, copper alloys and stainless steel in order to avoid the risk of stress corrosion.

5.3 Solvent cleaning

Solvents, by their very nature, are volatile organic compounds and are subject to close scrutiny by government bodies due to their ozone depleting and global warming potential. Some chlorinated solvents are still acceptable and established alternatives include hydrochlorofluorocarbons (HCFCs), aliphatic hydrocarbons and some specialised constant boiling blends. The use of HCFCs should only be regarded as a transition alternative due to the intention to phase them out by 2020.

Chlorinated solvents offer an advantage in that they tend to be usable in conventional degreasing equipment such as ultrasonic cleaners. Solvent degreasing must be carried out in a well-ventilated area and appropriate personal protective clothing should be used. The workplace exposure limits / threshold limit values shall be followed.

On completion of cleaning it is essential that all traces of solvent remaining are removed. When the favoured method of cleaning is to use a solvent, its choice will represent a compromise combination of relevant properties this has been highlighted in section 6. Any solvents used shall be of a stabilised grade of proven suitability.

Material compatibility, toxicity and environmental issues in the application, and waste disposal aspects must all be considered when choosing the most suitable solvent for a given cleaning application. It is important to ensure that the solvent is compatible with the materials used in the construction of the parts being cleaned. Unstabilised solvents can cause metal corrosion. The presence of moisture accelerates the corrosive effects of trichloroethylene and it is therefore essential that care is taken to maintain the quality of the solvents in use.

Flammability is an important safety issue with hydrocarbons. Alcohol, oil spirits, some solvents and dry residues of aqueous detergents are flammable with oxygen. These characteristics of flammability are well known. However if this type of product is used, the procedure for rinsing, purging and checking has to be carefully documented. It shall be ensured that after the complete procedure no residuals of flammable vapour or liquid remain in the equipment especially in complicated configurations, dead ends etc.

When non-flammable solvents are chosen, hydrocarbon-free grades should be used.

The recycling of solvents and their ultimate safe disposal must conform to national legislative requirements. Accurate records should be maintained with a view to establishing a mass balance. Where disposal of spent solvent is required, it will normally be necessary to employ an approved professional waste disposal agent. National legislation will normally stipulate the storage and transport requirements. All solvent, recovered solvent and waste must be clearly labelled. Solvent must never be discharged directly into drains, sewers or natural watercourses. Checks should be regularly carried out on the purity of solvent that is reused or has been recovered.

5.4 Detergent cleaning

Detergent cleaning is done in water solutions containing chemicals with different functions. It is normally performed in an alkaline environment, the higher the pH value, the better the degreasing efficiency. Common components in alkaline detergents and their main functions are shown in section 6. The most important detergent components are the surfactants. They decrease the surface tension of the water solution, penetrate the organic contaminants and make them disperse as small droplets into the water solution.

Proprietary synthetic detergents are available for use to clean different polymers, metals and alloys. It is most important the manufacturer's recommendations are complied with and also the effect on any non-metallic materials which are present.

5.5 Emulsion cleaning

Emulsion cleaner systems have three main components, water, an organic solvent and surfactants. They are used in two ways:

a) The solvent, emulsified in water, is applied in a manner similar to standard aqueous cleaners. The solvent is the main dirt dissolver and the surfactants work principally as emulsifiers.

b) water-free solvents with added emulsifiers are applied in concentrated form and then rinsed with water. The emulsifying of the solvent and cleaning products takes place when water is first added and in the subsequent rinsing stage. For safety and environmental reasons, solvents with high flash points and low vapour pressures are normally chosen. Examples of solvents are different high oiling hydrocarbons, citrus based terpenes and pine based terpenes. Other examples are esters and glycol ethers.

Proprietary emulsion cleaners are available to clean different polymers, metals and alloys. It is most important the manufacturers recommendations are complied with and also the effect on any non-metallic materials which are present.

5.6 High pressure hot water or steam cleaning

Hot water and steam cleaning may be used as a preliminary degreasing operation. However, this practice is not recommended as the only method, because the degreasing efficiency is low and drying after cleaning may be slow and difficult.

5.7 Safe disposal of cleaning agent

All material handling details should be highlighted in a company operational procedure and all users must be made aware of the proper methods for safe handling and disposal. Some of the cleaning agents used for oxygen service cleaning will require a full COSHH evaluation and procedures for dealing with emergencies fully documented. Gloves, goggles and vapour masks must be made available for all users. Use of these materials must take place in well ventilated areas.

Many of the cleaning materials used in mechanical cleaning have non-volatile qualities and can be safely disposed of using conventional methods of disposal. Some granular material used in tumbling or blast cleaning may be able to be recovered for repeated use by the manufacturer or supplier. Often this is as expensive as replacement with new product but will reduce landfill alternatives.

Chemical cleaning agents are supplied with material disposal information along with containment and labelling requirements. Care must be taken if attempting to reduce the strength of the chemical by adding water. This often increases the volume of chemical required to be disposed. Some local authorities have recycling centres capable of taking in and disposing of the chemicals. These must be dealt with by direct contact with staff at the recycling centre and not allowed to enter into general refuse disposal or sewerage systems. Disposal into watercourses attract very heavy fines and is no longer tolerated as a credible method.

Solvent disposal should be handled by specialist disposal companies recommended by the supplier of the solvent. Incorrect disposal can lead to heavy fines and increased global warming issues or ozone depletion. Many of the solvents used today are subject to continued evaluation and changing protocol. It is incumbent on the user to ensure that they have the latest information on solvents and disposal of solvents.

6 Cleaning materials

6.1 Mechanical cleaning materials

The products listed here used in mechanical cleaning processes shall be free from oil and grease:

a) Copper slag particles

b) Aluminium oxide

c) Glass beads

d) Sand

Metallic shot may be used. However, it is not recommended for small installations. Complete removal must be assured to safely use metallic shot.

Wire brushes manufactured from brass, bronze, copper or stainless steel wire are recommended. Brushes should be clean and in good condition.

Wire brushes used on carbon steel must not be used on any other surface.

6.2 Chemical cleaning solutions

6.2.1 Acid *solutions*

Typically acid solutions used for cleaning components for diving systems are drawn from the following list:

a) Chromic acid - H_2CrO_4;

b) Hydrochloric acid - HCl;

c) Hydrofluoric acid - HF;

d) Nitric acid - HNO_3;

e) Sulphuric acid - H_2SO_4;

f) Phosphoric acid - H_3PO_4.

Manufacturers will stipulate which acids are compatible with their components, sub-systems or systems and this should be the first point of reference. As a general guideline the following table may be used for metals and acid compatibility.

Table 1. - Acids used for metal cleaning

Metal	Good	Additional note
Carbon steel	Inhibited HCl, H_2SO_4	Dilute alkali dip to neutralise. H_3PO_4 can be used as a passivation treatment to prevent flash rusting.
Low alloy steel	Inhibited HCl, H_2SO_4.	Dilute alkali dip to neutralise. H_3PO_4 can be used as a passivation treatment to prevent flash rusting.
Stainless steel	HF, H_2CrO_4, H_2SO_4.	HNO_3 will brighten the metal. HCl can cause stress corrosion.
Copper alloys	HCl, H_2SO_4.	HNO_3 will brighten the metal. Toxic fumes from copper pickling HCl requires an inhibitor to restrict reaction.
Aluminium alloys	H_3PO_4 & HNO_3	Will brighten the metal.
Bronze & brass	HNO_3.	HCl can cause stress corrosion.

6.2.2 Alkaline *Solutions*

Aqueous solutions of the following alkaline chemicals, often as mixtures, used for grease and oil removal from components for diving systems are drawn from the following list:

a) Sodium hydroxide - NaOH (caustic soda);

b) Sodium carbonate - $NaC0_3$ or sodium bicarbonate - $NaHC0_3$ (buffer solution);

c) Sodium phosphate - Na_3PO_4 (water softener, emulsifier and buffet);

d) Sodium silicates - $NaSi0_4$ (emulsifiers and buffets).

Table 2. – Alkaline Solutions used for metal cleaning

Metal	Good	Additional note
Carbon steel	NaOH, $NaC0_3$, Na_3PO_4, $NaSi0_4$.	Do not allow to dry, rinse off with fresh water.
Low alloy steel	NaOH, $NaC0_3$, Na_3PO_4, $NaSi0_4$.	Do not allow to dry, rinse off with fresh water.
Stainless steel	NaOH, $NaC0_3$, Na_3PO_4, $NaSi0_4$.	Clean thoroughly to avoid stress corrosion.
Copper alloys	NaOH, $NaC0_3$, Na_3PO_4, $NaSi0_4$.	Clean flowing water. Hot water will aid drying
Aluminium alloys	$NaC0_3$, $NaSi0_4$.	A dilute nitric acid dip to remove any remaining deposit after the alkali dip. Rinse well with water.

6.3 Solvents

Table 3 - Industrial solvents

Characteristic		Solvent (1)	
	Trichloroethylene (TCE)	Perchloroethylene (Tetrachloroethylene)	Methylene chloride (Dichloromethane)
Chemical formula	C_2HCl_3	C_2Cl_4	CH_2Cl_2

Boiling temperature (°C at 1,013 mbar)	87	121	40
Vapour pressure (mbar at 20°C)	73	19	474
Solvent capacity Kauri-butanol coefficient [2]	130	90	136
Long-term exposure limit (8-hour TWA reference point) [3]	100 ppm / 550 $mg.m^{-3}$	50 ppm / 345 $mg.m^{-3}$	100 ppm / 350 $mg.m^{-3}$
Short-term exposure limit (15-minute reference period) [3]	150 ppm / 820 $mg.m^{-3}$	100 ppm / 689 $mg.m^{-3}$	300 ppm / 1060 $mg.m^{-3}$
Evaporation rate Diethylether = 1	3,8	11	1,8
Flash point °C	None	None	None
Minimum ignition temperature [4] (°C at 1,013 mbar)	410	None	606
Flammability limits in air (% volume) [5]	8 - 10.5%	None	14 - 22%

NOTE 1: Potential users should determine whether the solvent has been declared acceptable by National authorities. Solvents shall only be used in stabilised form.

NOTE 2: The Kauri-butanol (KB) coefficient is a measure of the relative solvent power of the chemical. It corresponds to the volume of solvent which when added to a solution of kauri gum in butanol causes commencement of cloudiness in the solution. The better the solvent action, the higher the KB value.

NOTE 3: Workplace exposure limits are those cited in GB by the Health & Safety Executive in the 2005 edition of EH40 Workplace exposure limits. The terminology used varies in different countries. The values used should always be those cited in the National regulations relating to the country in which operations are being conducted.

NOTE 4: The minimum ignition temperature is the temperature of the most flammable mixture with air or oxygen.

NOTE 5: The figures quoted are the lower and upper flammability limits expressed as a percentage by volume of the vapour in air.

As production of volatile organic compounds are slowly being phased out there are a number of replacements coming on to the market. The obvious approach is to contact specialist material handlers for the most up-to-date information. Further information may be found in the Solvent Emissions Directive (SED) from H&SE

Two products which replace VOC's are Solvent 702 and Solvent TMA. Both are non-hazardous, low odour, non-voc solvents with excellent solvency for oils and greases.

Solvent 702 – Typical Data

Table 4 – Non-Volatile Organic Compounds

Characteristic		Solvent

	Solvent 702	Solvent TMA
Optimum operating Temp.	60-80°C	60-80°C
Boiling temperature (°C at 1,010 mbar)	>220°C	>200°C
Flash Point	>100°C	>100°C
Freezing Point	<-10°C	<-10°C
Vapour Pressure @ 20°C	0.01mmHg	0.01mmHg
Specific Gravity	0.985	0.985
Viscosity (cP @ 25°C)	<10	<10
Auto ignition Temperature	>250°C	>250°C

Table 5 - Hydrochlorofluorocarbons (HCFCs)

Characteristic		Solvent (1)		
	2,2-Dichloro-1,1,1 trifluorothane (HCFC 123)	1,1-Dichloro-1-fluoro-ethane (HCFC 141b)	3,3-Dichloro-1,1,1,2,2 pentafluoropropane(HCFC 225 ca)	1,3-Dichloro-1,1,2,2,3 pentafluoropropane(HCFC 225cb)
Chemical formula	$C_2HCl_2F_3$	$C_2H_3Cl_2F$	$C_3HCl_2F_5$	$C_3HCl_2F_5$
Boiling temperature (°C at 1,013 mbar)	2	32 (2)	51,1	56,1
Solvent capacity Kauri-butanol coefficient (3)		61	34	30
Long term exposure limit (8 h TWA reference period) (4)	None published	None published	None published	None published
Short-term exposure limit (15-minute reference period) (4)	None published	None published	None published	None published
Flammability limits in air (% volume) (5)	None	5,6-17,7		
ODP (7) HGWP (8) POCP (9)	0,02 0,02	0,11 0,1	0,025	0,033

NOTE 1: Potential users should determine whether the solvent has been declared acceptable by National authorities. Solvents shall only be used in stabilised form.

NOTE 2: Not suitable for cold cleaning.

NOTE 3: The Kauri-butanol (KB) coefficient is a measure of the relative solvent power of the chemical. It corresponds to the volume of solvent which when added to a solution of kauri gum in butanol causes commencement of cloudiness in the solution. The higher this coefficient, the greater the solvent action.

NOTE 4: Workplace exposure limits are those cited in GB by the Health & Safety Executive in the 2005 edition of EH40 Workplace exposure limits. The terminology used varies in different countries. The values used should always be those cited in the National regulations relating to the country in which operations are being conducted.

NOTE 5: The figures quoted are the lower and upper flammability limits expressed as a percentage by volume of the vapour in air.

NOTE 6: The relative time of evaporation is the ratio between the evaporation time of the liquid concerned and that of diethylether at a temperature of 20±2° C and a relative humidity of 55 ±5%.
NOTE 7: Ozone depleting potential (ODP) is expressed relative to CFC- 11 (Fluorotrichloro-methane) = 1.

NOTE 8: Halocarbon global warming potential (HGWP) is expressed relative to CFC -11 = 1.

NOTE 9: Photochemical ozone creation potential (POCP) is a relative measure of the ability of volatile organic compounds to enter into reactions that lead to poor air quality due to the formation of low altitude ozone. The base is taken as ethylene = 100.

Table 6 — Miscellaneous solvents

Characteristic		Solvent (1)	
	Acetone	Isopropanol (Propan-2-ol)	Methyl ethyl ketone (Butan-1-one)
Chemical formula	C_3H_60	C_3H_80	C_4H_60
Boiling temperature (°C at 1,013 mbar)	56,5	82,5	79,6
Vapour pressure (mbar at 20°C)			
Solvent capacity Kauri-butanol coefficient (2)			
Long-term exposure limit (8-hour TWA reference point) (3)	500 ppm / 1210 $mg.m^{-3}$	400 ppm / 999 $mg.m^{-3}$	200 ppm / 600 $mg.m^{-3}$
Short-term exposure limit (15-minute reference period) (3)	1500 ppm / 3620 $mg.m^{-3}$	500 ppm / 1250 $mg.m^{-3}$	300 ppm / 899 $mg.m^{-3}$
Evaporation rate Diethylether = 1			
Flash point °C			
Minimum ignition temperature (°C at 1,013 mbar)			
Flammability limits in air (% volume) (4)	3 - 11	2,5 - 12	1,8 -11,5
Natural Oils			

NOTE 1: Potential users should determine whether the solvent has been declared acceptable by National authorities. Solvents shall only be used in stabilised form.

NOTE 2: The Kauri-butanol (KB) coefficient is a measure of the relative solvent power of the chemical. It corresponds to the volume of solvent which when added to a solution of kauri gum in butanol causes commencement of cloudiness in the solution. The higher this coefficient, the greater the solvent action.

NOTE 3: Workplace exposure limits are those cited in GB by the Health & Safety Executive in the 2005 edition of EH40 Workplace exposure limits. The terminology used varies in different countries. The values used should always be those cited in the National regulations relating to the country in which operations are being conducted.

NOTE 4: The figures quoted are the lower and upper flammability limits expressed as a percentage by volume of the vapour in air.

6.4 Detergents/Emulsions

Table 7 — Common components in alkaline detergents and their main function

Main Function	Examples of common components
Dirt Dissolvers pH Raising Agents	Sodium Hydroxide Potassium Hydroxide Sodium Carbonate Sodium Silicate
Dispersers	Surfactants (Tensides) Sodium Silicate Polyphosphates
Softeners	Polyphosphates Borates Glyconates
Corrosion Inhibitors	Sodium Silicate Borates Amines
Wetting Agents	Polyuphosphates Glyconates Surfactants (Tensides)

6.4.1 **Proprietary** *oxygen cleaning products available*

It is difficult to create a list of products that are available on the open market with a view to keeping it current but most technicians will settle on a preferred choice either by recommendation or research. The technician should research the product fully and understand the constituent compounds, where it lies in the aqueous detergent group and what it can and cannot be used on. This information then forms part of the material handling or COSHH documentation for the workshop. These products are far more environmentally friendly than the raw solvents listed in 6.3.

6.4.2 Typical *available cleaning products listed by trade name*

a) Blue Gold industrial cleaner;

b) Delta Omega Technologies DOT 111-113;

c) GMC Oxy-Safe Citrate cleaner;

d) Simple Green;

e) Trisodium Phosphate (TSP).

f) Gentech – good replacement for Trichloroethylene (TCE)

7 Verification of cleanliness

7.1 Quantitative and qualitative and tests

Testing falls into two distinct areas, quantitative and qualitative. For the verification of equipment for oxygen service seen at the scale of the diving industry requirement a quantitative approach will be of little use in a small workshop but may be of merit in large volume and repeatable processes. All testing requires that the technician has training and experience in interpreting the results.

7.1.1 Quantitative *tests*

Quantitative tests are undertaken by taking a test sample and flushing the test sample with a suitable high-purity and higher solvency solvent. The high-purity solvent is then analysed to record traces of contamination. If the sample passes then the batch from where the sample is taken is also passed.

7.1.2 Qualitative *tests*

Qualitative tests require that all components are inspected using one of the noted procedures and inspection results recorded.

7.2 Direct visual inspection with white light

Visual inspection using white light can be used to detect the presence of some oils, greases, corrosion, erosion, staining, swarf, particulates, lint fibres, etc. The cleanliness of internal surfaces such as pipe bores may be inspected using an endoscope. It is essential that any instrument used is oxygen clean so that the introduction of inadvertent contamination is avoided during inspection.

7.3 Direct visual inspection with ultra violet (black) light

UV light exposure causes most hydrocarbon or organic oils to fluoresce. Inspection is carried out by directing a light source of wavelength 0.36 µm to 0.39 µm at the surface from a distance of around 100 mm to 200 mm in total or near darkness. Any evidence of fluorescence indicates unacceptable surface cleanliness.

Excessive exposure to direct or reflected ultraviolet light can cause eye and surrounding skin tissue damage. Use care and limit the exposure whilst following manufacturer's instructions.
NOTE: This method will not detect silicone or fluorocarbon greases.

7.4 Wipe test

The cleanliness of items possessing a proportionally large surface area may be inspected by wiping over the surface with a lint-free cloth or other wipe media. The wipe can be inspected using techniques described in 7.2 or 7.3.

7.5 Water break test

Where aqueous-based cleaning has been carried out, the water-break test is a simple and effective way of indicating surface cleanliness. Wet a horizontal surface with a fine atomized spray of purified water. If the surface is contaminated, a continuous film will not form or will rapidly break up into small beads of water. Properly applied, the water break test is able to detect contamination to around mean levels of between 30 mg/m^2 to 60 mg/m^2. To prevent false indications of cleanliness, it is essential that all traces of detergents or surface active agents should be removed by rinsing in flowing clean water, before the test is carried out.

8 Frequency of cleaning

Once the SCUBA system has left the hands of the technician and is placed in the hands of the owner there is little regulated control over ability to retain the oxygen service status. Contaminants can enter the oxygen clean system through filling from a contaminated source, unregulated breakdown of the system or through poor diving aftercare technique. Visual inspection is therefore the primary means of inspection.

8.1 Cylinders

When an oxygen service SCUBA cylinder/s are presented for filling with oxygen, heliox, trimix or oxygen enriched air the technician filling the cylinder/s must carry out a visual inspection of the cylinder valve prior to connection to any filling system delivering greater than 21% oxygen.

The technician should ask if the cylinder has been introduced to a hydrocarbon producing gas source.

If there is any suspicion of contamination the technician has the right to refuse to fill the cylinder.

The technician should ask that a visual inspection using methods from 7.2, 7.3, 7.4 or 7.5 be carried out to satisfy the safety procedure of the centre only if it cannot be ascertained that oxygen service integrity has been maintained.

In the case of properly maintained cylinders where oxygen service has been maintained the frequency of cleaning shall fit with the cycle of visual and hydraulic inspections carried out on the cylinder. The acceptable maximum timeframe between cleaning for oxygen service is 15 calendar months.

8.2 SCUBA Regulators

SCUBA regulators used in oxygen service will be maintained following the manufacturers specified timeframe as stipulated in service details for the particular model.

Only oxygen compatible components from the manufacturer will be fitted to the particular model.

Where items such as high pressure hoses must be placed in oxygen service it is often more economical to replace with a new oxygen clean and compatible hose than to attempt to clean the original hose.

8.3 Equipment used for the storage or delivery of oxygen above 21%

Equipment used by a technician for oxygen delivery to an oxygen service system shall be visually inspected for contamination prior to each use.

A regime of maintenance shall be in place documenting strip-down, cleaning and oxygen service rating. The frequency of this service will be dictated by the level of use but should not exceed 12 calendar months.

9 Packaging and labelling

9.1 Packaging

New components from manufacturers should be packaged in material that will not contaminate the component BS 5N 100-7 which states that it should be wrapped and sealed in low-density polythene of a minimum of 65 µm thickness.

Items such as regulators or cylinders should have all orifices that open to the oxygen service internally sealed with removable oxygen clean plastic caps or plugs.

Cleaned items for storage should be sealed as above and stored until required out of direct sunlight.

9.2 Labelling

Labels must not use an adhesive which could transfer to the component or item stored. Information tags, securely attached to the product or bag containing the component are suitable.

New items will be labelled on the external packaging with words denoting that the item is cleaned for oxygen service. The serial number, date of cleaning, reference to the process undertaken and sign off on completion should also be part of the label. This may be in the form of a barcode where there are multiple units supplied.

Components for storage should also be labelled with a reference to the cleaning process, the date of cleaning and part number.

Scuba cylinders should carry a label denoting that the item is in oxygen service and must clearly state the following information:

a) A statement saying that the cylinder has been cleaned and placed in oxygen service. Any accidental or intentional hydrocarbon contamination must be reported when next presented for filling;

b) Additional words stating that the cylinder is suitable to use with oxygen, heliox, trimix or oxygen enriched air;

c) A visually simple label showing the date of the cleaning service undertaken. Punched/cut out month and year will be suitable;

d) Service centre details, contact number and technician reference;

e) A statement showing that the oxygen service rating is for a maximum of 15 months **from** date of cleaning.

Scuba regulators should be denoted as oxygen service by use of a fixed plastic tag or ring attached to the regulator body. The tag or ring will carry a reference to the service centre to allow for cross referencing of oxygen service. This tag or ring should be anti-tamper.

Appendix 1.0

Procedure for Oxygen Cleaning

For the Oxygen Service Technician there are three important terms that must be learned and applied in all instances:
1. **Oxygen Clean**
2. **Oxygen Compatible**
3. **Oxygen Service**

Oxygen Clean

Oxygen clean refers to the absence of contaminants from a system or a component. There are certain materials that have a very low temperature of ignition and/or can react violently in the presence of oxygen. The fact that we are dealing with pressurized systems increases the risk of these contaminants igniting. Where it may be impossible to 100% clean scuba systems, we must take every precaution and follow proper procedures to keep the levels of contamination as low as possible. Although one may think of hydrocarbons as fuel, they are often not as apparent as one may think. There are many types of contaminants, both organic and inorganic, that can enter a system. The job of the Oxygen Service Technician is to know how to best clean these contaminants from the system as well as to make sure the work area is free of these contaminants, in order to prevent possible recontamination after cleaning. Below is a list of some of the most common materials that might contaminate a scuba system:

Dust, hair, dandruff, lint, wood, paper, saliva, finger prints, rust, sand, soot, burrs, paint, scale, pollen, insects, metal filings, sealants, ceramic chips, glass particles, grease, solvents, mineral oils.

Particles of plastic, cleaning detergents, hydrocarbon-based lubricants, carbon dust from compressor filters, residual materials from tumbling or shot blasting a cylinder, hydrocarbons from poorly filtered or substandard air sources

Where oxygen cleaning is mandatory, it is strongly suggested that it be performed on a regular basis or where it can fit into a regular service pattern of cylinder examination. This will prevent the insidious buildup of contaminants over a long period of time. The periods utilized must be viewed in all cases as absolute maxima.

What is the minimum standard for when oxygen cleaning is required? NOAA, OSHA, and other technical and Nitrox training certification agencies have agreed that if the oxygen content of the breathing mixture entering the cylinder is 40% or less, all scuba equipment may be used without the necessity of oxygen cleaning. **However, manufacturers' specifications and guidelines supersede this minimum standard and must be fully adhered to by the Oxygen Service Technician**. If at any point, such as in the case of partial pressure blending, oxygen is introduced into a system or cylinder; then the system or cylinder must be oxygen clean and have only oxygen compatible components. SITA strongly suggests that any scuba system or component used with oxygen percentages greater than 21% be oxygen cleaned in accordance with UK regulations and recommendations.

Oxygen Compatible

Material that will not react with oxygen at the pressures and temperatures specified for that piece of equipment is considered oxygen compatible:

Buna-N (neoprene) O-rings and seats are not usually considered oxygen compatible by all manufacturers for most scuba applications and equipment.

Viton and Teflon are very common plastics used in Oxygen Service.

Standard silicone based lubricants are not considered oxygen compatible.

Common oxygen compatible lubricants include: Halocarbon 25-55 O-ring lubricant, Christo-Lube, Krytox, Kel-F and Flu-Lub.

In all cases the Oxygen Service Technician must strictly adhere to the manufacturer's specifications and guidelines for the materials and parts that are specified for oxygen compatibility.

Oxygen Service

Oxygen service means that a system or system component is suitable to use in an oxygen environment.

Oxygen Clean + Oxygen Compatible = Oxygen Service

The Oxygen Service Technician

The Oxygen Service Technician must always take care to only use the proper cleaning procedures, equipment, solvents, lubricants and parts as specified by the guidelines of any particular manufacturer of equipment being cleaned.
An Oxygen Service Technician will not only need the cleaning materials & equipment to service the scuba equipment properly, but will also need to take appropriate steps to ensure that cross contamination does not take place once the equipment is serviced.

The Oxygen Service Technician must follow all manufacturers' specifications for the use of their equipment with oxygen enriched mixtures. Many manufacturers require special cleaning, lubricants, and components if the percentage of oxygen used is greater than 21%. The Oxygen Service Technician must also be certified as a service technician with the manufacturer of the equipment being prepared for Nitrox/Oxygen use.

When regulators are being serviced & cleaned for the use of oxygen enriched mixes or pure oxygen:

1) The Oxygen Service Technician must be certified by the manufacturer to work on that particular brand and model.

2) The Oxygen Service Technician must follow ALL the guidelines and procedures found in the service manual of the manufacturer for that particular regulator without variation.

Of those manufacturers that endorse their regulators for mixed gas use, many specify the limits of oxygen percentage in the breathing mix within which particular models of their regulators are to be used. In this case, the breathing mixture must not exceed the limits or range specified by the manufacturer for that particular model of their regulator.

The Workstation

The area used by the Oxygen Service Technician should be kept as contaminant free as possible. Surfaces should be cleaned by the technician on a regular basis. While working, windows and vents must be checked so as not to introduce any airborne contaminants.

Work surfaces should be covered with clean plastic or other easily cleanable surface and should be inspected for cleanliness using an UV/white light before use.

Work tools must be oxygen clean before doing any oxygen servicing. It is suggested that a separate set of tools be used for oxygen cleaning and servicing. These tools should be kept separate from other tools in the workspace. They also should be oxygen cleaned on a regular basis. This goes for all equipment used in the cleaning and servicing processes.

Lastly, the Oxygen Service Technician should wear clean, powder free, latex or plastic gloves when servicing equipment and handling tools in order to prevent contamination from fingerprints and body oils.

There is further reference to the workstation in Section 4.1 of Diving Equipment in Oxygen Service.

Cleaning Solvents

There are many types of cleaning solvents that have been used for oxygen cleaning. The practice of using volatile, toxic, and/or environmentally unfriendly solvents is non-acceptable. Early in technical diving history, solvents such as trichloroethylene were used, sometimes with disastrous results.

The choice of the solvent will depend on several factors:
1. The degree of contamination
2. The type of contaminant(s)
3. The nature of the material being cleaned (composition)
4. The size of the object

5. Guidelines and procedures specified by the particular manufacturer
6. National, regional, and local laws governing the use of specified solvents for the purpose of oxygen cleaning
7. Availability of particular solvents

Commonly Used Oxygen Cleaning Solvents

SD-13
Simple Green
Distilled Water
Naval Oxygen Cleaner
Trisodium Phosphate (TSP)
Blue Gold Industrial Cleaner
GMC's Oxy-Safe Citrate Cleaner
Delta Omega Technologies DOT 111-113

With any cleaning solvent, the Oxygen Service Technician must follow the manufacturers' guidelines for the appropriate use of the solvent. The work area must be adequately ventilated when solvents are in use. In addition, it is important that any cleaning agents, such as solvents which are used in the cleaning process are properly removed on completion by rinsing and purging with hydrocarbon free, dry air.

Note**:** *Not all solvents on the market are appropriate for oxygen servicing scuba equipment. Use an approved solvent when oxygen servicing diving equipment!*

Cleaning Equipment

The equipment used by the Oxygen Service Technician varies widely, according to the type of equipment being serviced as well as the guidelines of specific manufacturers. Some of the equipment required is widely available. Other equipment may need to be ordered directly from the manufacturer of the scuba equipment being serviced.

The list below contains the more common types of equipment that may be needed by an Oxygen Service Technician. It is in no way all inclusive or comprehensive.

Common Oxygen Service Equipment

• Magnifier
• Steam lance
• Cylinder tumbler
• Cleaning solvents
• Ultrasonic cleaner
• Protective eyewear
• Clean toothbrushes
• Cylinder drying rack
• Clear zip-lock plastic bags
• Lint- free wipes
• White inspection light
• OEM Service Manuals
• Cylinder cleaning whip
• Ozone cleaning system
• Regulator Servicing Tools

- Powder-free latex gloves
- Appropriate tumbling media
- Ultraviolet (UV) inspection light
- O_2 clean (hydrocarbon-free) air supply
- Visual inspection labels
- Oxygen rating labels
- Un-waxed butcher paper – used for workstation preparation
- O_2 compatible anti-rusting agent such as GMC's Oxy-Safe Rust Inhibitor - Compound O
- Supply of O_2 compatible O-rings - usually Viton (sometimes EPDM O-rings) and specific OEM O-rings
- O_2 compatible lubricants such as: Halocarbon 25-55 O-ring lubricant, Christo-Lube, Krytox, Kel-F and Flu-Lub
- Oxygen compatible PTFE tape.

Although not always mandatory, an ultrasonic cleaner is a valuable asset to an Oxygen Service Technician.

Inspection Lights

Inspection lights used for equipment and for cylinder inspection should be kept clean of contaminants in order not to contaminate any oxygen cleaned scuba equipment or parts.

White Incandescent or Fluorescent Inspection Lights

This light is used for the direct inspection of cylinders and parts. Sometimes the inspection light can be used with magnification to get a closer view of small parts or spaces. This light will show some of the most obvious common contaminants of scuba equipment. It should be of sufficient brightness to fully illuminate the surface of the equipment or parts being inspected.

Ultraviolet (UV) Inspection Lights

This light should be used with prescribed UV blocking eye protection. Under an ultraviolet light most contaminants, not visible under the white inspection light, will glow (fluoresce), especially hard to see oils. Some synthesized compressor oils will not glow under an ultraviolet inspection light.

Note: The following information is given as general guidelines in the preparation of various components of a scuba system for oxygen cleaning and/or oxygen service. In all cases where there is any variation from the Original Equipment Manufacturers' (OEM) procedures and guidelines, the Original Equipment Manufactures' (OEM) procedures and guidelines will supersede the general guidelines given in this chapter.

OXYGEN CLEANING CYLINDERS:

1) **Visual Inspection:** This should be done by a properly trained Cylinder Test Technician. Technical agencies have training programmes and IDEST has an outstanding programme for certifying qualified Cylinder Test Technicians.
   a) If the cylinder is beyond the periodic inspection and test date or there is evidence of pitting, the cylinder must first be hydro-tested.
   b) If there is evidence of rust or aluminum oxide powder, the cylinder will either need to be cleaned conventionally using one of two methods (whichever may be appropriate for the type and degree of contamination found):
      i) Tumbling with the appropriate tumbling media
      ii) Whip cleaning using a suitable flail
      iii) Internal shot blasting
   c) If the cylinder is new, or if it is found to be clean of rust or aluminum oxide powder, then it may be taken to step # 2 The Tumbling Wash.

A good inspection light is needed to see what may lurk inside the opening of a scuba cylinder.

2) **The Tumbling Wash:**
   a) Vent Cylinder
   b) Remove the cylinder valve.
   c) Clean lubricant (i.e. silicone grease) from the neck threads of the cylinder using a lint free swab.
   d) Using a clean toothbrush, or similar brush, soaked in the appropriate solvent (i.e., Simple Green at a concentration of 10 parts water to 1 part Simple Green) clean any remaining lubricant from the neck threads. If using other cleaners, be sure to follow the recommendations of the manufacturer.
   e) Prepare the cleaning solution according to the manufacturer's instruction. (i.e., Simple Green: 15 ml per 4 litres).
   f) Pour approximately 2 litres into the cylinder and put a plug into the neck to prevent fluid loss during tumbling
   g) Tumble the cylinder for 15 – 20 minutes at 60-90 rpm.
   h) Drain the cylinder into a catch pan.
   i) Examine the drained contents -
      i) If they are discolored or dirty, rinse the cylinder and repeat steps "d" through "h" of this section again until the drained cleaning solution no longer show signs of dirt or discoloration. Comparison with a sample of unused solvent will assist this decision process.
      ii) If there are no signs of dirt or discoloration move on to the next step.
   j) Flush the interior of the inverted cylinder in 2 cycles of 2 minutes each using a small clean hose. Pause between each flushing to allow all the water to completely drain from the cylinder. For the flushing, use cold water as this will help prevent flash oxidation of the metal interior.

k) Inspect the cylinder interior with a both a white light and UV light to assure there are no visible contaminants remaining.
l) At this point, an oxygen compatible non-toxic rust inhibitor formulated for scuba cylinders may be used on steel cylinders (such a GMC's Compound O) to prevent flash rusting during the drying stage.
m) IMMEDIATELY dry the scuba cylinder either with:
    i) A compressed air jet using oxygen compatible (hydrocarbon free) air.
    ii) A hot air cylinder dryer producing hydrocarbon free air designed for oxygen servicing (temperatures of the dryer must not exceed 162° C or 325°F when used on aluminum cylinders or the excessive heat may weaken the alloy).
n) Inspect the cylinder interior with a both a white light and UV light to ensure there are no visible contaminants remaining following the drying process.
o) Keep the cylinder capped with an oxygen clean plug after drying to prevent contamination before reinserting the cylinder valve.
p) Check threads using an appropriate Go-No Go
q) Reinsert the cylinder valve and tighten to the correct torque.

OXYGEN CLEANING CYLINDER VALVES:

1) **Valve Disassembly and Cleaning:**
    a) Disassemble the cylinder valve completely.
    b) Discard all the old O-rings.

c) Pre-clean by using an approved degreaser solvent (i.e. Simple Green).
d) Any salt, calcification, or encrustation should be removed with an appropriate mild acid bath (ChromeSafe™, mild nitric acid, or acetic acid). This can be done by soaking in a clean bath container or, preferably, by using an ultrasonic treatment.
e) This is to be followed by a clean water rinse to ensure all residues and cleaning agent is removed.
f) All parts must then be oxygen cleaned in a detergent bath using an appropriate degreaser, such as those used in cylinder cleaning. This may be done either by:
i) Soaking and hand scrubbing.
ii) Ultrasonic detergent bath.
g) Check components are clean using U/V and white light
h) Blow with hydrocarbon free air both inside and out of all parts until completely dry.
i) Where there is a possibility of contamination transfer on the gloves worn by the technician it is essential that contaminated gloves are disposed of and new ones worn. Pay particular attention to steps d to e and e to f.

2) **Valve Assembly:**

a) During the assembly process the Oxygen Service Technician should wear a pair of powder-free latex gloves, to avoid the possibility of recontamination from such things as fingerprints.
b) Lubricate all moving parts with a small amount of oxygen compatible grease (Halocarbon 25-55 O-ring lubricant, Christo-Lube, Krytox, Kel-F and Flu-Lub).
c) Replace o-rings with the appropriate Viton o-ring.
d) Store in a clean zip-lock bag until ready to place in cylinder in order to keep the valve clean and prevent contamination.

To prevent contamination store the oxygen clean valve in a zip lock bag until ready to insert in the cylinder neck.

OXYGEN CLEAN CYLINDER AND VALVE ASSEMBLY

1) Very lightly lubricate the valve threads with an oxygen compatible lubricant, (Halocarbon 25-55 O-ring lubricant, Christo-Lube, Krytox, Kel-F and Flu-Lub).
2) Check threads using an appropriate Go-No Go
3) Reinsert the valve into the cylinder. Tighten firmly only to the point that the O-ring bottoms out. Tighten to the correct torque. Take care not to over-tighten the cylinder valve.
4) The converted cylinder should now be appropriately marked with the:
a) Visual Inspection and Oxygen Rating Label.

b) The appropriate label for the gas it will contain.

5) Fill the cylinder slowly with oxygen compatible (hydrocarbon free) air to 7 bar or 100 psi.
6) Slowly drain the cylinder.
7) Repeat step # 4 & step # 5 above, three to four times.
8) Store the cylinder with at least 35 bar or 500 psi of oxygen compatible air until ready to fill with the desired gas mix. At this time conduct a leak test of the valve to EN 14189. The gland, seat and cylinder neck should show no signs of leakage.

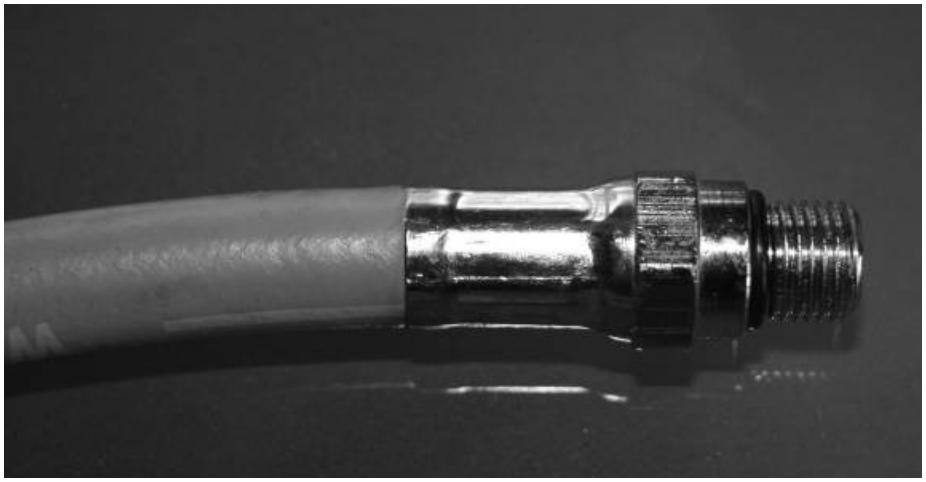
Do not fill to any greater pressure than 35 bar or 500 psi with any gases until the leak test has been completed.

OXYGEN CLEANING LOW PRESSURE HOSES

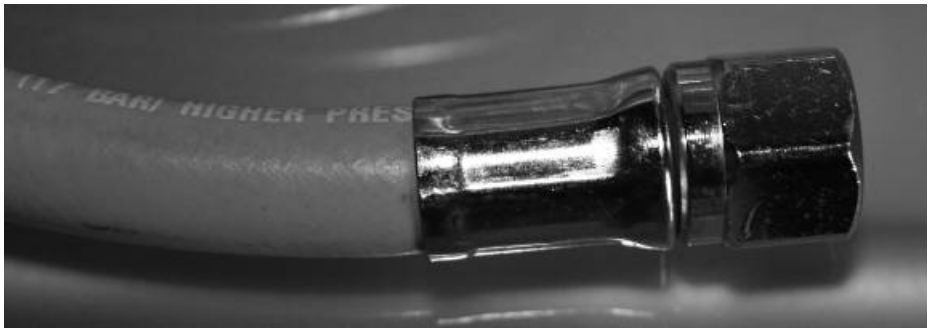
Low pressure hose showing both end fittings.

1) Pre-clean both hose fittings by using an approved degreaser solvent (i.e. Simple Green).
2) Any salt, calcification, or encrustation on the hose fittings should be removed with an appropriate mild acid bath (ChromeSafe™, mild nitric acid, or acetic acid). This can be done by soaking in a clean bath container or, preferably, by using an ultrasonic treatment. This is to be followed by a clean water rinse.
3) Run an appropriate solvent solution (i.e., Simple Green at a concentration of 10 parts water to 1 part Simple Green) through the hose in both directions. If any discoloration of the solvent occurs or if debris is present in the fluid as drained from the hose, continue until the fluid runs clear.
4) If there are any signs of either external or internal damage to the hose, the old hose must be replaced with a new hose.
5) From this point on the Oxygen Service Technician should wear powder-free latex gloves to prevent contamination.
6) Both hose ends must then be oxygen cleaned in a detergent bath using an appropriate degreaser such as those used in cylinder cleaning. This may be done either by:
   a) Soaking and hand scrubbing with a nylon brush (clean tooth brushes work well).
   b) Ultrasonic detergent bath.
7) Rinse the hose well with heated, distilled water, both inside and outside.
8) Blow with hydrocarbon free air both inside and out of all parts until completely dry. Check end fittings are clean using white or U/V light.

9) Replace the O-rings with the appropriate manufacturer supplied or Viton O-rings.
10) Make sure all O-rings are lubricated very lightly with the appropriate oxygen compatible lubricant (Halocarbon 25-55 O-ring lubricant, Christo-Lube, Krytox, Kel-F and Flu-Lub).
11) Store with the end fittings wrapped in cellophane until you are ready to reassemble equipment.

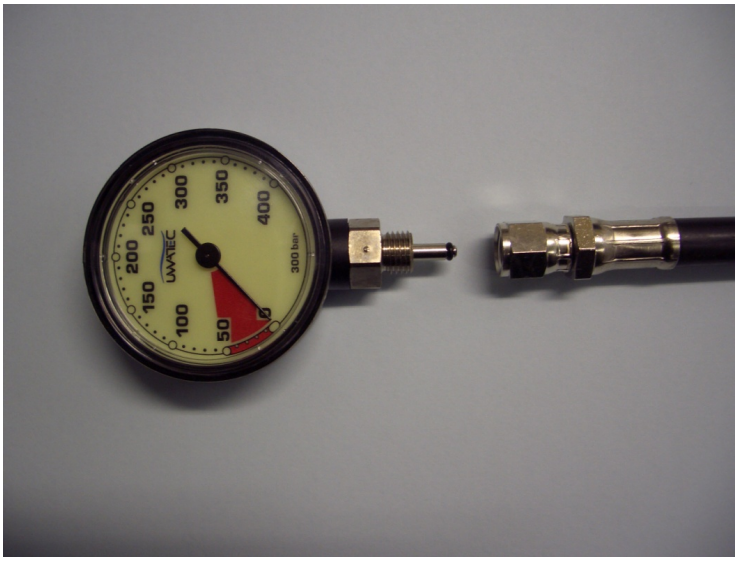


Low pressure hose – regulator end fitting.

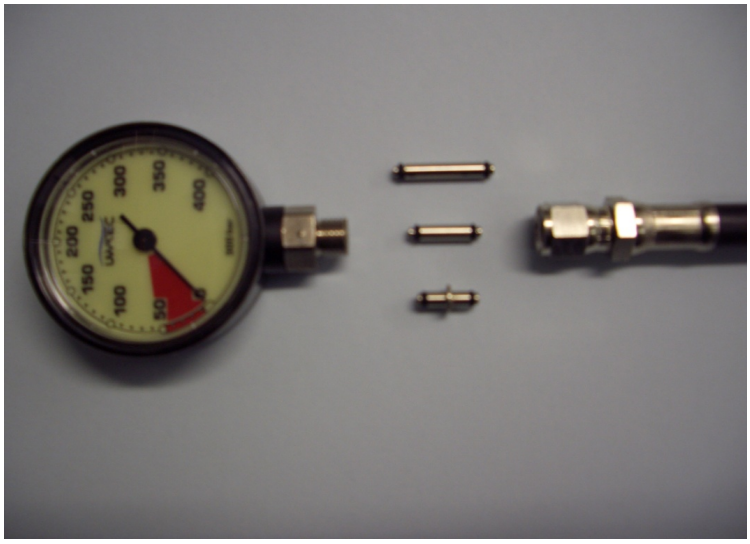


Low pressure hose – second stage fitting end

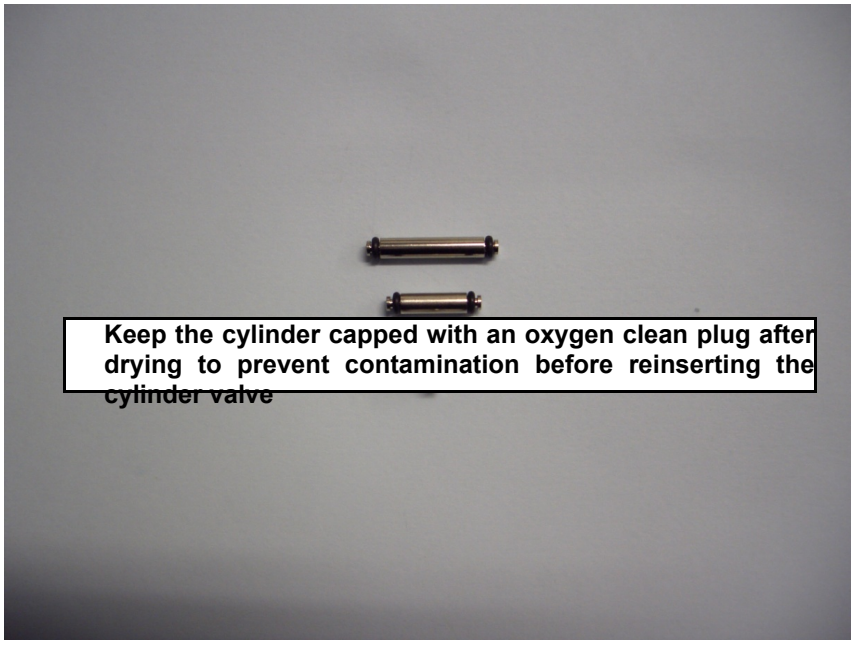
OXYGEN CLEANING HIGH PRESSURE HOSES & GAUGE FITTINGS



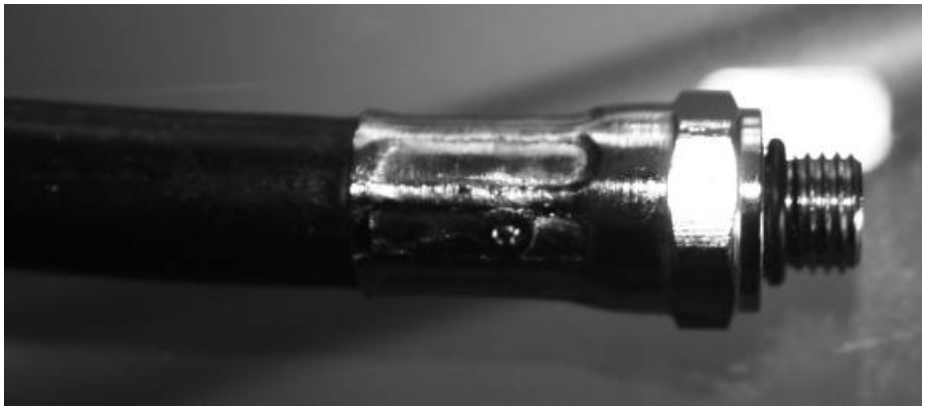
1) Remove the pressure gauge from the end of the hose.



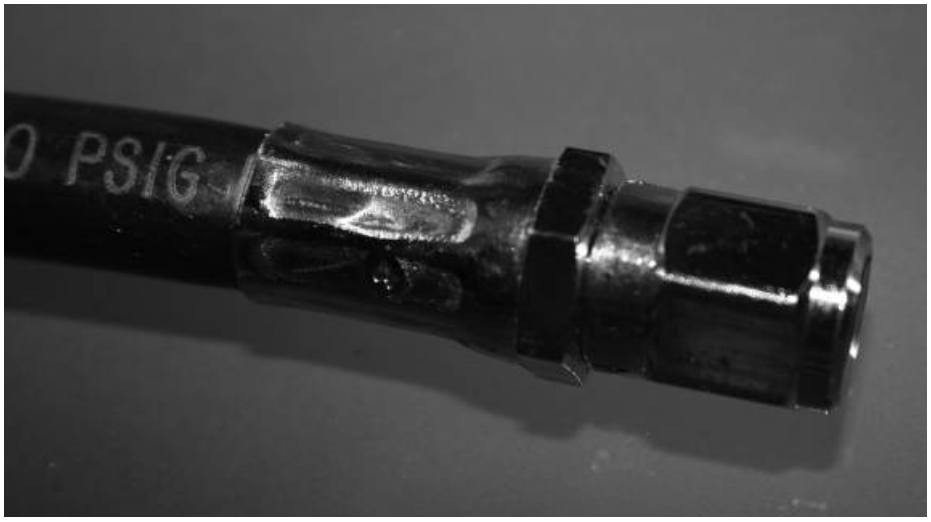
2) Pull the air spool carefully from either the pressure gauge or the high pressure hose fitting.
3) Remove the o-rings from the air spool.
4) Wipe any grease or debris from the air spool, hose fittings and gauge fittings using lint-free
5) Wipe any grease or debris from the air spool, hose fittings and gauge fitting using a lint-free swab.



6) Under magnification, inspect the air spool for signs of wear or damage. If damage or wear is found, replace.
7) Inspect the high pressure hose for signs of damage. If damage is found replace.
8) Inspect the pressure gauge to make sure the retaining fitting is tight and the pressure relief plug is intact.
9) Pre-clean hose fittings and pressure gauge fitting by using an approved degreaser solvent (i.e. Simple Green). Take care not to get any fluid up into the pressure gauge itself.



High pressure hose – regulator fitting



High pressure hose – pressure gauge fitting

10) Any salt, calcification, or encrustation on the hose fittings or pressure gauge fitting should be removed with an appropriate mild acid bath (ChromeSafe™, mild nitric acid, or acetic acid). This can be done by soaking in a clean bath container or, preferably, by using an ultrasonic treatment. This is to be followed by a clean water rinse. Take care not to get any fluid up into the pressure gauge itself.
11) Hose fittings, the air spool and the pressure gauge fitting must then be oxygen cleaned in a detergent bath using an appropriate degreaser such as those used in cylinder cleaning. Take care not to get any fluid up into the pressure gauge itself. This may be done either by:
    a) Soaking and hand scrubbing with a nylon brush (clean tooth brushes work well).
    b) Ultrasonic detergent bath.
12) Rinse hose fittings, pressure gauge fitting, and the air spool with distilled water.
13) Dry the pressure gauge fitting by blowing the outside with hydrocarbon free air and carefully swabbing the internal portion with a dry lint-free swab.
14) Store the cleaned pressure gauge in a clean zip lock bag until you are ready to reassemble.
15) Dry the air spool carefully by blowing with hydrocarbon free air both internally & externally. On completion check components are clean with white and UV light.
16) Store the air spool in a clean zip lock bag until you are ready to reassemble.
17) Oxygen clean the high pressure hose by:
    a) Filling the hose completely with an approved oxygen cleaning degreaser at the correct
    b) concentration. This may be done by injecting the cleaning solution with a cooking baster or large syringe into the female end of the hose.

Female end opening of the high pressure hose

Male end opening of high pressure hose

c) Once filled the hose must be allowed to soak in a tub of cleaning solution for several hours or by cleaning in an ultrasonic cleaner for 15 minutes.
d) Drain the cleaning fluid from the hose.
e) With a clean cooking baster or syringe, inject distilled water into the female end until the entire hose is full.
f) Soak the hose in a container of hot distilled water at a temperature of approximately 66° C for 30 minutes.
g) Remove the hose from the bath and drain.
h) Repeat for 3 to 5 cycles; fill the hose using the baster or syringe with distilled water and drain. This must be repeated until the water shows no sign of wash agent (foam, color, or odour).
i) Wipe the outside of the hose with a lint free cloth.
j) Replace the o-rings on the hose fittings with the appropriate manufacturer supplied or

Viton O-rings.

k) Very lightly lubricate the o-rings and fitting threads with an oxygen compatible lubricant (Halocarbon 25-55 O-ring lubricant, Christo-Lube, Krytox, Kel-F and Flu-Lub).

l) Attach the high pressure hose to the high pressure port of an oxygen clean regulator first stage. This first stage must also have a second stage attached so it may be purged to release system pressure.

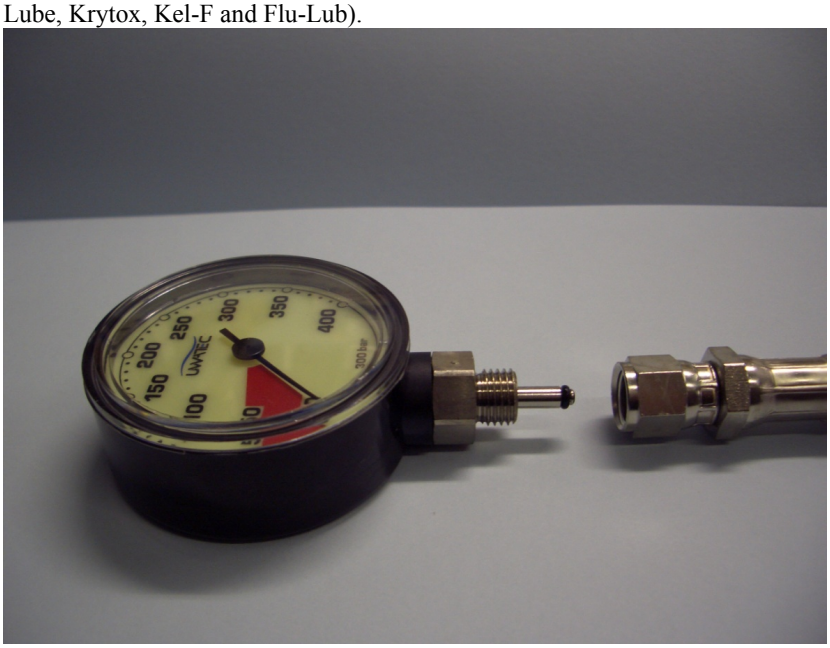
m) Attach the regulator to a cylinder filled with hydrocarbon free air at a pressure of no more than 135 bar or 2000 psi.

n) Secure female end of hose to prevent excessive movement and while firmly holding it slowly open the cylinder valve allowing the air to blow out any remaining moisture in the high pressure hose. Continue until there is no sign of moisture left in the hose.

o) Store the hose with the end fittings cover with cellophane until you are ready for reassembly.

18) Reassemble the high pressure hose, air spool and pressure gauge:

a) Lightly lubricate the appropriate manufacturer supplied or Viton o-rings for the air spool with the appropriate lubricant (Halocarbon 25-55 O-ring lubricant, Christo-Lube, Krytox, Kel-F and Flu-Lub).



b) Carefully insert the air spool into the recess of the pressure gauge end fitting.

c) Match up the high pressure swivel fitting with the air spool and gauge fitting and hand tighten until snug.

d) While holding the gauge fitting retaining nut with a wrench, use a torque wrench on the hose fitting and tighten to 5.78 Newton metres or 50 inch pounds.

e) Replace the O-ring on the male end fitting of the high pressure hose with the appropriate manufacturer supplied or Viton O-ring that has been lightly lubricated the appropriate lubricant (Halocarbon 25-55 O-ring lubricant, Christo-Lube, Krytox, Kel-F and Flu-Lub).

f) Keep the male fitting of the high pressure hose covered with polythene until you are ready to install in on the regulator first stage.

OXYGEN CLEANING AND SERVICING REGULATORS

NOTE: When regulators are being serviced & cleaned for the use of oxygen enriched mixes or pure oxygen:

1) The Oxygen Service Technician must be certified by the manufacturer to work on that particular brand and model.

2) The Oxygen Service Technician must follow ALL the guidelines and procedures found in the service manual of the manufacturer for that particular regulator without variation.

NOTE: Not all manufacturers endorse the use of their regulators, or particular models in their regulator line for use with oxygen enriched mixes or pure oxygen. If the regulator is not endorsed for mixed gas diving or oxygen use, then it must not be serviced for these applications.

NOTE: Of those manufacturers who do endorse their regulators for mixed gas usage, many specify the limits of oxygen percentage in the breathing mix within which particular models of their regulators are to be used. In this case, the breathing mixture must not exceed the limits or range specified by the manufacturer for that particular model of their regulator.

General notes on oxygen cleaning and servicing regulators:

1) All parts used must be those specified by the manufacturer of the regulator.
2) Keep parts bag sealed until ready for use and/or in a clean zip lock bag.
3) When handling parts, wear powder-free latex or plastic gloves to prevent contamination.
4) When making final adjustments or flow bench testing, hydrocarbon free air should be used to prevent contamination.
5) Once serviced the regulator should be clearly labeled for Nitrox use and the range at which it may be used specified.
6) The dust cap should be placed in the first stage (the dust cap must also be oxygen clean).
7) The regulator should be kept in an airtight bag after cleaning while waiting for customer pickup.

Be Certified by the Manufacturer of the Equipment as a Service Technician and Follow All the Manufacturer's Guidelines and Procedures as They Apply to General Servicing and Oxygen Cleaning and Servicing

Proper Labeling

All cylinders must be properly labeled as to their use and gas mixtures. Each cylinder must be labeled with both a Content/MOD Label and a Visual Inspection and Oxygen Rating Label.

Other exact labeling requirements vary by country, region, and locality. Oxygen Service Technicians need to consult SITA/IDEST or HSE for exact labeling requirements for their area. The Oxygen Service Technician must also keep informed of changes in any national, provincial, regional, and local laws that may apply to labeling cylinders for mixed gas diving.

No cylinder should be filled that does not have both the Content Label and a current Visual Inspection and Oxygen Service Label. The cylinder must be properly labeled for the mixed gas use. Once the gas is analyzed, the cylinder must be labeled with the contents showing the oxygen percentage as well as the inert gases, The MOD (Maximum Operating Depth) must also be listed on the cylinder content label.

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Limiting Your Liability

It is important that Oxygen Service Technicians follow proper procedures and guidelines in order to limit liability. The following are some guidelines to follow in order to help stay within professional guidelines, procedures, and practices.

Keep Current with Applicable Laws and Regulations

The Oxygen Service Technician must be aware of any national, regional, provincial, or local laws and regulations that might apply. As these laws and regulations are subject to change, the Oxygen Service Technician must constantly monitor any changes that might be applicable. Although not totally inclusive, some of these laws and regulations may include areas such as:

- General and specific regulations that apply to oxygen cleaning and servicing.
- General regulations that apply to the scuba profession.
- Regulations that apply to chemicals and cleaning solvents the Oxygen Service Technician may use.
- Regulations that may apply to professional liability insurance.
- Regulations that apply to the proper storage of high pressure gases.
- Regulations that apply to proper labeling of various gases and mixtures.
- Regulations that apply to the quality of the gases used for mixed gas diving.
- Regulations that may apply to the transport of high pressure gas mixtures.
- Regulations that apply to the sale of services.
- Regulations that apply to servicing scuba equipment.
- Regulations that apply to blending, analysis, and sale of mixed gas.

Keep a Service Log

The Oxygen Service Technician should keep an up to date Service Log on all equipment serviced. This log should include such categories as:

- Date of service.
- Equipment owner.
- Dive certification level and verification of the owner.
- Type of equipment serviced and any serial numbers the components of the equipment may have.
- Type of service performed.
- Any special notes that may be appropriate to log about the service or equipment.

This Equipment Service Log can also be used as a sales tool to notify the customer of when service may again be required or recommended.

Keep a Gas Blender Log

The Oxygen Service Technicians may also be Gas Blenders. If involved in any way in gas blending they should also be certified as Gas Blenders. Whenever diving gases are mixed, filled, or sold the process should be logged.

A Gas Blender Log includes such categories as:

- Cylinder serial number
- Owner

- Owner's level of certification & card #
- Requested mix
- Analysis from Gas Blender with MOD listed
- Dated signature of when the Gas Blender analysed the mixture
- Verification analysis from customer
- Dated signature of when the customer analysed the mixture

Final Note: The information in this document is given as general guidelines in the preparation of various components of a scuba system for oxygen cleaning and/or oxygen service. In all cases where there is any variation from the Original Equipment Manufacturer's (OEM) procedures and guidelines, the Original Equipment Manufacture's (OEM) procedures and guidelines will supersede the general guidelines given in this chapter.

Appendix 2.0

Bibliography

BS EN 132, Respiratory protective devices - Definitions of terms and pictograms

BS EN 144-3, Respiratory protective devices - Gas cylinder valves - Part 3: Outlet connections for diving gases Nitrox and oxygen

BS EN 145, Respiratory protective devices - Self-contained closed-circuit breathing apparatus compressed oxygen or compressed oxygen-nitrogen type - Requirements, testing, marking

BS EN 250, Respiratory equipment - Open-circuit self-contained compressed air diving apparatus - Requirements, testing, marking

BS EN 720-2, Transportable gas cylinders - Gases and gas mixtures Part2. Determination of flammability and oxidizing ability of gases and gas mixtures

BS EN 738-2, Pressure regulators for use with medical gases Part 2: Manifold and line pressure regulators

BS EN 1089-2, Transportable gas cylinders - Gas cylinder identification (excluding LPG) - Part 2: Precautionary labels

BS EN 1089-3, Transportable gas cylinders - Gas cylinder identification (excluding LPG) - Part 3: Colour coding

BS EN 13949, Respiratory equipment - Open-circuit self-contained diving apparatus for use with compressed Nitrox and oxygen - Requirements, testing, marking

BS EN 14143, Respiratory equipment - Self-contained re-breathing diving apparatus

BS IEC 60877, Procedures for ensuring the cleanliness of industrial-process measurement and control equipment in oxygen service

BS 8478, Respiratory protective devices – Breathing gases for diving and hyperbaric applications

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