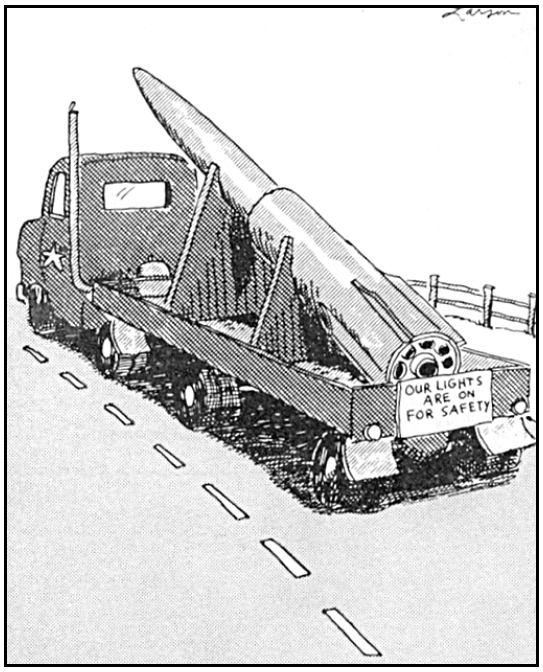
Section 8 — Plant Equipment and Maintenance Procedures



Larson.[1]

[1] Copyright © The Far Side, Last Impressions, 2002, Larson. (Stolen and used without permission!)

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1 CHAPTER 1 – APPLICATION & USE OF PLANT & EQUIPMENT

INTRODUCTION

ADAS COMPETENCY

Plant, equipment and maintenance procedures.

Supervise the application and safe use of plant and equipment utilised in a dive operation within area of responsibility.

Ensure equipment is maintained and serviced under a planned maintenance program with appropriate documentation.

Keep up to date of developments of new plant and equipment, and procedures associated with their use.

Ensure appropriate qualifications and/or training of personnel prior to use or maintenance of any plant or equipment.

GENERAL

Knowledge of plant, equipment and procedures is essential to planning and conducting dive operations effectively. As dive supervisor you need to:

- ✔ supervise the application and use of all **plant and equipment** utilised in the dive operation within your area of responsibility,
- ✔ supervise the application and use of all **maintenance procedures** utilised,
- ✔ keep **up to date** with developments of new plant, equipment and maintenance procedures, and
- ✔ ensure appropriate **qualifications and/or training** of personnel prior to use of any plant, equipment or maintenance procedures.

APPLICATION

To be able to supervise the application and use of plant and equipment effectively, it is important to be familiar with all the plant and equipment utilised in the dive operation under your control. This does not necessarily mean that you need to be experts in the use of the equipment or operation of plant yourself, but you do need to have a good understanding of both plant and equipment. You should be able to:

- ✔ list all plant and equipment likely to be used in dive operations under your control, and
- ✔ describe the basic function and correct use of all plant and equipment used in your dive operations.

PLANT AND EQUIPMENT

GENERAL

As a dive supervisor you should be thoroughly familiar with all the standard plant and equipment used in your diving operations. The basic plant and equipment is described in the

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Occupational diving operations standard, AS/NZS2299.1:1999[2]. Sections 3, 4, 5 and 6 specify the minimum equipment requirements for various diving operations.

- ✔ Section 3 *General Procedures and Equipment* covers general equipment requirements, responsibilities, inspection, cleaning and storage requirements (3.8); first aid and medical equipment (3.9); and the minimum general diver's equipment required for diving operations (3.12).
- ✔ Section 4 *Compression (Recompression) Chambers* specifies the circumstances requiring the availability of a compression chamber (4.1); the chamber design, construction, fittings and services (4.2); medical equipment requirements (4.4) and Transfer-under-pressure (TUP) requirements (4.5).
- ✔ Section 5 *Specific Requirements for SSBA Diving Operations* specifies minimum underwater equipment requirements for SSBA diving operations (5.4); the compressed breathing gas supply (5.6); the air compressor systems requirements (5.7); and the cylinder gas systems (where used) (5.8).
- ✔ Section 6 *Specific Requirements for SCUBA Diving Operations* 6.4 specifies the minimum underwater equipment requirements for SCUBA diving operations (6.4); and the lifeline requirements (6.5).

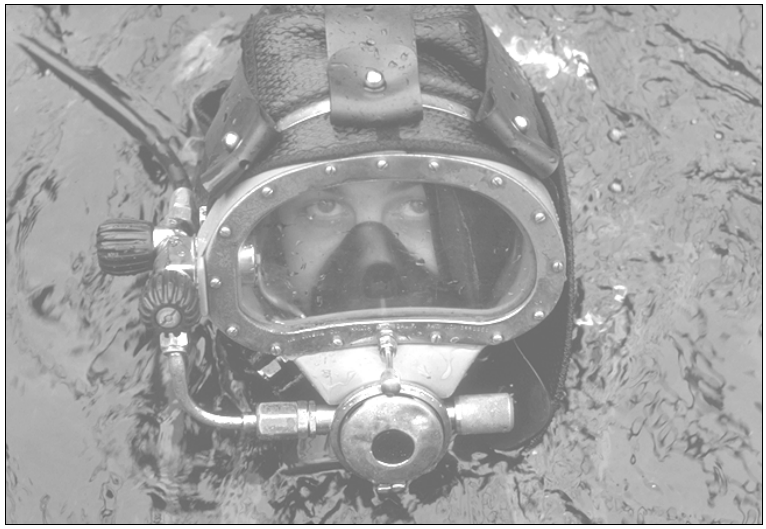

Figure 1: Kirby Morgan MK10 Band Mask. A commercial diver wearing a Kirby Morgan MK10 Band Mask. Note the oral nasal area and the "spider band" holding the mask in place.

DIVE EQUIPMENT

AS/NZS2299.1 provides guidance as to minimum equipment requirements. For example, SSBA equipment requirements are given in clause 5.4, p33 and include:

- ✔ an incompressible helmet or full-face mask
- ✔ inlet and exhaust valves
- ✔ diver's hose
- ✔ breathing gas supplies

[2] Hereafter referred to as AS/NZS2299 - information on the relevant section included as a footnote.

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- ✔ demand breathing gas supply device
- ✔ a harness
- ✔ a lifeline
- ✔ two-way voice communication with the surface

Scuba equipment is outlined in clause 6.4.1 and includes fins and a buoyancy control (BC) device. Although these are only specified for scuba in the Standard, fins and BCs are good practice in most SSBA diving operations, and their use should be encouraged.

You will generally need to select the type of equipment you will use, as well as any additional requirements over and above the minimum specified in the Standard.

Another example is the selection of a bail-out system, which is specified in Clause 5.6.3.3. There are a number of different options that can be used. You need a good understanding of each of the systems available. Although all systems are similar in terms of ease of use and accessibility, there may be some other factors that affect your choice. The following diagrams assist in the selection of the appropriate bail-out system.

BAIL-OUT SYSTEM SELECTION GUIDE

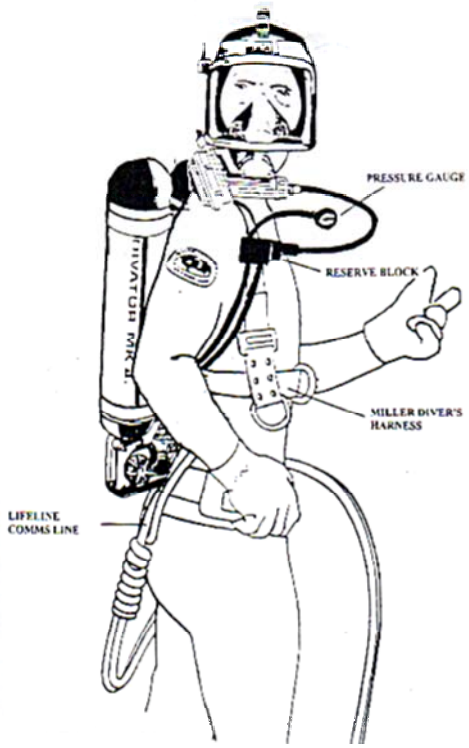

Figure 2: Aga Scuba

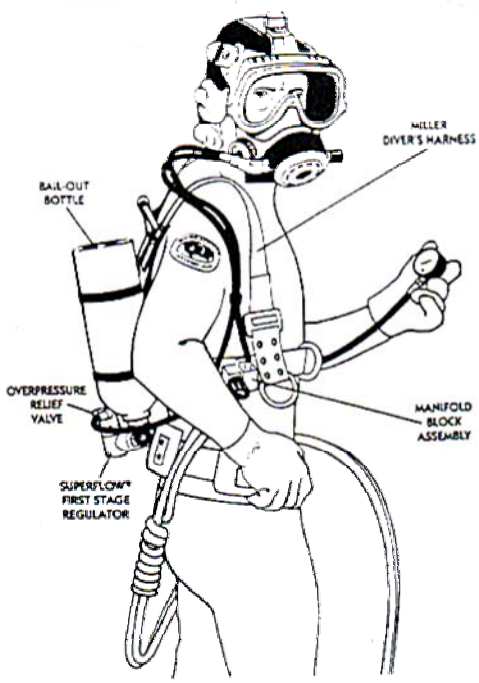

Figure 3: Exo 26 Manifold Block Assembly

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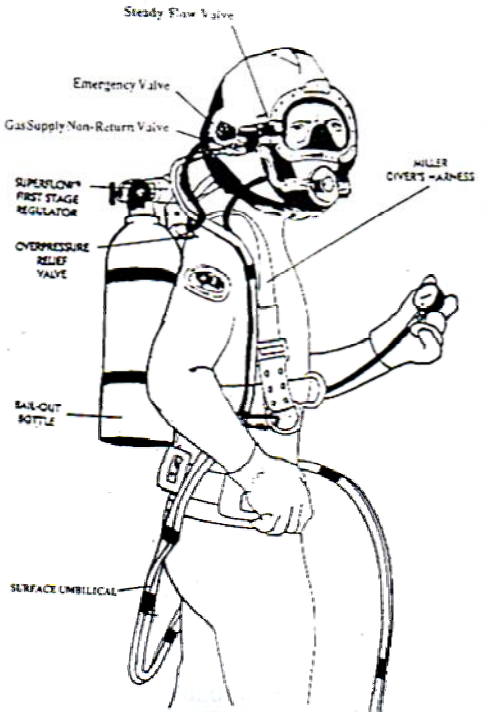


Figure 4: Superlite Surface Supplied.

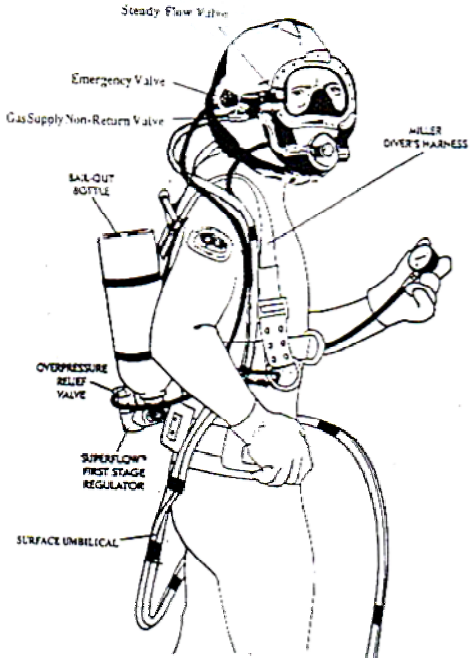
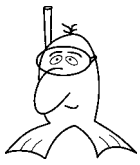


Figure 5: Superlite (Inverted Cylinder).

Factors to consider are:



- ✔ What system is the diver familiar with already? (In an emergency, it is easier for the diver to use a system he/she is familiar with, reducing the likelihood of something going wrong).
- ✔ What system is already in use in the organisation? (Maintaining consistency across the organisation improves familiarity, makes training easier and makes maintenance more efficient).
- ✔ Visibility. In nil visibility, standard scuba cannot be worn because you cannot read the gauge.
- ✔ Cylinder size. There is no guidance given in AS/NZS 2299.1 on this issue. However, workplace custom in some companies is to use the small 20 cuft pony bottles. You will need to assess whether this is adequate for the dive. For a deep dive, this is not satisfactory and a larger cylinder should be used.

OTHER PLANT AND EQUIPMENT

In addition to these basic minimum dive equipment requirements, it is likely that you will have other plant and equipment requirements for the dive operation. Some examples included in AS/NZS 2299.1 are:

- ✔ compressor (clause 5.7)
- ✔ cylinders (clause 5.8)
- ✔ breathing gas test equipment (clause 3.13.2)
- ✔ communications equipment (clause 3.6)
- ✔ depth measuring equipment (clause 3.5)

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- ✔ thermometer for measuring water temperature (clause 3.7)
- ✔ pressure gauges (clause 3.14)
- ✔ air supply for pneumatic tools (clause 3.15)
- ✔ lifelines (clause 6.5)

Information on the basic function, correct use and maintenance of plant and equipment can be obtained from the manufacturer's instructions, organisational policy and procedures and in formal accredited training. These will assist in selecting the appropriate specialist equipment and using it effectively.

Some things to consider when selecting the special plant and equipment required for a dive operation are:

- ✔ the minimum requirements laid down in AS/NZS2299.1
- ✔ depth of dive
- ✔ length of dive
- ✔ decompression stoppages required
- ✔ nature of work
- ✔ tools required undertaking the tasks
- ✔ any special licences required for tools, explosives, dangerous goods handling or transportation, or rigging and crane operations
- ✔ experience and competence of divers
- ✔ local conditions

MIXED GAS AND REBREATHING APPARATUS

■ GENERAL

Although mixed gas is beyond the scope of AS/NZS2299.1, it is becoming more popular for use in both commercial and recreational diving. The associated plant and equipment need careful maintenance and procedures due to the hazardous nature of pure oxygen.

Although you may not currently use mixed gas or rebreathing apparatus in your position as dive supervisor, it is helpful to have a general awareness of some of the features and safety issues of these.

The use of any mixed gases requires special training which is beyond the scope of this course. The information in this section is for general understanding only – if you intend to use mixed gases you must make sure that you and your team are trained appropriately.

Mixed gases are designed to improve safety and increase bottom time.

There are a number of systems in use. Some of these are:

- ✔ Nitrox – a nitrogen oxygen mix
- ✔ Trimix – nitrogen, oxygen, helium mix

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✔ Heliox – helium, oxygen mix

NITROX

Air is a mixture of roughly 79% nitrogen and 21% oxygen. The term Nitrox simply refers to a mixture of nitrogen and oxygen, so strictly speaking, air is Nitrox. However, the term Nitrox is generally used for a mixture that is greater than 22% oxygen. Other terms are Enriched Air, Enriched Air Nitrox or EANx, where x is a variable standing for the fraction of oxygen value.

The two most commonly used Nitrox mixes are EAN 32 and EAN 36. These are also known as NOAA Nitrox I (NNI) and NOAA Nitrox II (NNII)[3].

EAN32 is well suited for recreational dives. EAN36 is used for extended scientific or research dives at moderate depths. At greater depths, the higher concentration of oxygen in EAN36 leads to a greater risk of oxygen toxicity.

The two main advantages of Nitrox are:

✔ more bottom time; and/or

✔ improved safety by reducing the risk of decompression sickness.

> Note that if the bottom times are the same, there will be an improved margin of safety when using nitrox compared to air. However, if nitrox is used to extend the bottom time, the safety margin is reduced, as more nitrogen is absorbed.

The limitations of nitrox are:

✔ requires additional training

✔ requires special equipment

✔ costs more than air

✔ may not always be readily available

✔ increases risk of oxygen toxicity

The issues for the dive supervisor are in planning the nitrox dive. The key issues are:

✔ Determining the primary goal – more bottom time or improved safety.

✔ Deciding which tables to use (equivalent air depth (EAD) with standard air tables; combined air/EANx tables; CNS "clock" exposure time table – to manage oxygen exposure).

✔ Deciding whether to use nitrox-programmable dive computers.

✔ Managing exposure to nitrogen.

✔ Managing exposure to oxygen (analyse the partial pressure of oxygen of the nitrox mixture to properly manage exposure to oxygen. Pulmonary oxygen poisoning occurs after long exposure to partial pressures of oxygen in excess of 0.6 bar. CNS oxygen poisoning occurs if the partial pressure oxygen exceeds 1.6 bar).

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[3] Nitrox was pioneered by the US government's National Oceanic and Atmospheric Administration (NOAA), hence the alternate names.

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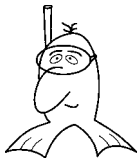
✔ Managing equipment issues (cylinder markings, increased oxidation and wear, risk of fire or explosion).

NITROX OPERATIONS - DEFINITIONS

AIR	Normoxic air – 21% Oxygen, 79% Nitrogen
EAD	Equivalent Air Depth. When breathing oxygen Enriched Air the equivalent air depth comparing the partial pressure of Nitrogen in the gas mixture
EANx Training	Certification of diver for use of Oxygen Enriched Air. This includes a demonstrated knowledge of the history, development, blending and safe usage of the gas, plus practical experience with the gas mixture
MOD	Maximum Operating Depth. The maximum depth the gas may be used at to avoid the partial pressure of Oxygen exceeding 1.5 ATA
NITROX	Oxygen enriched air. Where the percentage of Oxygen varies between 22% and 40%
NOAA	(United States) National Oceanographic and Atmospheric Administration
OXYGEN ENRICHED AIR	Oxygen – Nitrogen gas mixture where the percentage of Oxygen varies between 22% and 40%
UPTD	Unit of Pulmonary Toxicity Dose. Used to calculate the amount of Oxygen allowable before whole body or pulmonary Oxygen toxicity occurs
Oxygen Compatible	All components compatible with 100% oxygen, including o- rings, seats and lubricant
Oxygen Clean	Cleaned with special solvents to remove hydrocarbon
Oxygen Service	Designed for use with 100% Oxygen – is both Oxygen compatible and Oxygen clean

NITROX OPERATIONS - PERSONNEL



In addition to the requirements of AS/NZS 2299.1, personnel in diving operations using Nitrox mixes must be trained and certified in the techniques and mixes in use in the operation. This includes the diver, stand-by diver and supervisor. The attendant must be familiar with the hazards particular to the gas mixture in use and the corresponding actions to be taken.

■ TRIMIX AND HELIOX

Air or Nitrox should not be used below 50 msw[4]. Nitrox is generally not used below 40 msw, as the best mix for 50 msw without exceeding a partial pressure of 1.5 bar is only 25% oxygen (CNS oxygen poisoning may occur if the partial pressure of oxygen exceeds 1.6 bar). This small addition is not worth the cost and effort.

4 IMCA D014, Section 7.1.2.

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Diving at depths greater than 50 msw is beyond the scope of this manual. More information on appropriate mixes to use below this depth can be obtained from IMCA. There is also an interesting website http://www.cisatlantic.com/trimix/trimix.html[5] which explains the use of Trimix. Another reference is "Mixed Gas Diving" by T. Mount & B. Gilliam.

REBREATHERS

Rebreathing systems operate on the principle that the human body only absorbs part of the oxygen that is breathed in with each breath. Exhaled air contains a substantial amount of oxygen that is wasted in an open-circuit system. A rebreather recycles this air by passing the exhaled air through a soda lime cartridge to absorb the carbon dioxide and returns the purified air to the breathing circuit.

The advantages are that this extends the length of time that the air supply will last and extends the depth range. It also substantially reduces the noise, as there are very few bubbles produced. The inhaled air is moist and warm due to the chemical reaction involved in the absorption of carbon dioxide. This avoids the dry throat that often accompanies open circuit systems.

Disadvantages include cost and extra training required. The system is also generally more bulky than a standard SCUBA cylinder. There is also the issue of redundancy. In other words, if you extend the capability of the diver with a mixed gas rebreather, what do you do if the rebreather fails? Currently in the United States divers are doing up to 22 hours at depths up to 80 metres in caves. If they get a failure at maximum penetration they are not able to carry enough bail out open circuit gas redundancy so their solution is to carry two complete rebreathers. One is likely to be completely redundant, but is necessary for the safety of the diver.

PROCEDURES AND CHECKLISTS

FUNCTION AND CORRECT USE

It is a requirement of AS/NZS2299.1 that the supervisor "shall ensure that any equipment is of a type and capacity suitable for the job. The supervisor, diver and diver's attendant shall know the capabilities and limitations of any equipment they use."

It is therefore vital that you make sure that you familiarise yourself thoroughly with all equipment used in dive operations within your area of responsibility.

The correct use of the equipment is vital for diver safety. To effectively supervise the use of equipment, the dive supervisor needs to have a thorough knowledge of the function and correct use of each piece of equipment in use in the dive operation. AS/NZS 2299.1 specifies that "*the dive supervisor shall be experienced in the diving techniques which may be used, and in the equipment and procedures used in the diving operations to be performed.*"[6] Note that AS2299.1 has force of law in most Australian States, so this clause has important implications. If you are not experienced with equipment you intend to use in a dive operation, you must organise to have some training in the equipment, or to work under the supervision of someone who has the relevant experience.

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5 Accessed Aug 2002. This site and the opinions contained herein are those of a third party. ADAS cannot guarantee the information and takes no responsibility for accuracy, currency, reliability or completeness.

6 AS/NZS 2299.1:1999, c 2.1.2, p 10.

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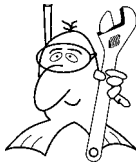
The other important reason for understanding the function and correct use of dive equipment is to assist in selecting the most appropriate equipment. For example, in a deep dive in cold water it may be necessary to consider special equipment to protect the diver from hypothermia. Experience with the different options will assist you to determine whether a dry suit will be adequate, or whether a hot suit is necessary.

CHECKLISTS

Sometimes problems are caused by incorrect setup, so it is important to have clear procedures for divers to follow when setting up or checking their equipment. Checklists are a useful tool to assist in this – these should be laminated and kept in an easily accessible place. AS/NZS2299.1 requires inspections to incorporate a list of essential pre-dive checks and requires the list to be provided and maintained at each dive location[7].

The major disadvantage with checklists and procedures is that it is common for people not to use them properly, and just tick off each step without really checking. It is your job as supervisor to ensure that divers undertake the checks properly. It may be simply a matter of reminding them occasionally of the importance of following the proper procedures, or it may be necessary to supervise their work more closely – either by observation, or by undertaking a final check yourself.



EXAMPLE: PRE-DIVE EQUIPMENT CHECKLIST

EQUIPMENT	CHECKLIST
Panel	secure the panel
	all valves closed – particularly Kluge valves
	regulator decreased to minimum
	remove caps – use two spanners
	fit umbilical – tie off – use two spanners
	fit two HP cylinders
	open cylinder gently and record pressure
	use change over valve to select red or blue – gently
	increase pressure regulator to desired setting and record
	blow through umbilical by opening lever on/off valve
	report to Supervisor

[7] AS/NZS2299.1:1999, c 3.8.2, p 15.

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EQUIPMENT	CHECKLIST
Helmet	disinfect with Metis disinfectant inspect seals and general condition test check valve de-fog connect umbilical and tighten silicon spray comms plug and connect tape comms plug test comms, diver number = comms number test breathe – check breathing adjustment in spider OK and available report to Supervisor
Compressor	level compressor and secure check motor oil level check compressor oil level fit petrol fit snorkel up-wind, secure connect air hose and lock tema on compressor connect compressor to panel choke on – fuel on –kill switch on – throttle 2/3 on drains open start unit – close drains run up to pressure and check blow off close choke as appropriate report to Supervisor

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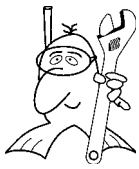
EQUIPMENT	CHECKLIST
Bail-out rig	harness and lifeline
	fit cylinder to BC
	fit bail out regulator c\w pressure relief valve
	test pressure and record
	connect BC inflator and test
	connect drysuit inflator if required
	knife, weights, fins, torch, carabina and computer
	report to Supervisor

EXPANDED CHECKLIST

Sometimes it is helpful to use a combination of a checklist approach and a more explanatory approach.

EXAMPLE: OPERATION OF A PORTABLE COMPRESSOR

It is imperative when dealing with expensive machinery such as a high pressure compressor that the operator be familiar with the manufacturer's handbooks. Read them carefully.



1. PRE START PROCEDURE

Before operating a compressor ensure the compressor is:

- ✔ far enough away from residents
- ✔ level
- ✔ positioned so inlet upwind from exhaust
- ✔ cool
- ✔ fitted with adequate safety guard

Drive Motor – check:

- ✔ oil
- ✔ fuel level
- ✔ direction of exhaust

Compressor:

- ✔ check oil
- ✔ repack filter
- ✔ rotate fan by hand
- ✔ open first interstage filter drains to take load off motor
- ✔ check filling pressures

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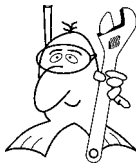

2 RUNNING PROCEDURE

After starting compressor, shut interstage separator. You will note that in some compressors there is an initial knocking noise. As the final cylinder requires air to drive it, until the air pressure is there it will knock.

Run the compressor up to pressure. Then check if pressure relief valves and all other parts are working adequately. Always keep a continual check on the wind direction, direction of sun, onlookers and unusual noises. Check valves every 30 minutes by feeling the cylinder heads which should not be too hot to touch.

Regularly bleed off separators and filters every 15-30 minutes.

FIRST AID AND MEDICAL EQUIPMENT

First aid and medical equipment is necessary at every dive site. The basic requirements can be obtained from the relevant occupational first aid codes of practice or from the relevant regulatory authority (for a list of these, see appendices). AS/NZS 2299.1 makes reference to this in Clause 3.9.1, and also specifies oxygen resuscitation equipment in Clause 3.9.2[8].

The assessment of potential hazards of a diving operation may also require additional specialist medical or first aid equipment. For example, the depth, length, nature of the work and local conditions may make it necessary to have a compression chamber on site. *Clause 4.1* of *AS/NZS 2299.1* specifies the requirements for a chamber on site and also for the conditions for procedures and transport to an off site chamber[9]. *Clause 4.4* specifies a compression chamber medical kit[10] and *Appendix H* gives guidance as to what this should contain.[11]

You will need to make sure that you identify all the equipment you need for a dive operation and that you have appropriate manufacturer's instructions, organisational procedures, checklists and any other relevant information for that equipment. This will form part of your dive planning (see chapter on dive planning).

8 AS/NZS2299.1:1999 p. 15

9 AS/NZS2299.1:1999 p. 24

10 AS/NZS2299.1:1999 p. 29

11 AS/NZS 2299.1:1999, p. 137

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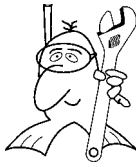
2 CHAPTER 2 - MAINTENANCE

INTRODUCTION

As dive supervisor, you will need to ensure that the plant and equipment your team uses is maintained properly in accordance with manufacturer's requirements and legal requirements. This will include being able to:



- ✔ Ensure equipment is maintained and serviced in accordance with **legal requirements and a planned maintenance program** and documentation maintained appropriately.
- ✔ **Troubleshoot** any problems associated with plant and equipment malfunction.
- ✔ Carry out basic on-site **maintenance** of plant and equipment within your capabilities and in accordance with manufacturer's instructions and organisational policies and procedures.

LEGAL REQUIREMENTS FOR PLANT AND EQUIPMENT

It is a requirement of legislation to ensure that all plant and equipment is properly maintained, tested and certified.

This comes under OHS legislation and under other legislation applicable to diving by reference to the Standards. *AS/NZS 2299.1* requires that plant and equipment shall be maintained in accordance with the manufacturer's instructions (*Clause 3.8.1 (a)*). It also refers to a number of other Standards, such as *AS/NZS 1337* (*Clause 3.12.3.3 (j)* and *3.12.3.4 (j)), AS2030.1 (Clause 5.8).* An interesting point to note is that *AS/NZS 2299.1* specifically directs that the Standard *AS 4484* shall **not** be used as it gives the same colour coding for oxygen-nitrogen mixtures as for air.

In some instances, *AS/NZS 2299.1* specifies the required maintenance, testing or certification. An example of this is gauge calibration (*Clause 3.14.1*). Calibration, testing and certification of pressure gauges should be included in the planned maintenance program.

PREVENTIVE MAINTENANCE PROGRAM

A preventive or planned maintenance program will help to ensure safe and efficient dive operations. There should be a series of checks and maintenance for each item of plant and equipment. This should include legal requirements for testing and certification. The maintenance schedule is likely to include weekly, monthly, three monthly, six monthly and annual checks.

The dive supervisor is likely to be closely involved in the weekly maintenance. This would include visual checks on condition, checks on oil levels and function tests.

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Although the planned maintenance at longer intervals is generally the responsibility of technicians, the dive supervisor should ensure that the maintenance schedule is followed and should have copies of completed checklists pertaining to maintenance.

TROUBLESHOOTING

GENERAL

While you are not expected to be an expert in troubleshooting all problems associated with plant and equipment malfunction, it is important to be able to recognise some of the more common equipment problems and malfunctions. Some of these problems that may need to be remedied on site are:

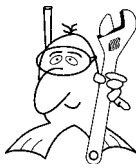
- ✔ Communications malfunction
- ✔ Compressor (filters)

If you have a problem with plant or equipment malfunction that you are unable to troubleshoot and remedy, it is critical to safety that you remove the item from use and tag or label it properly so that it is not inadvertently put back into service. All plant and equipment used in connection with diving operations shall not be used if it can be demonstrated that such plant or equipment is not in a safe working condition.

Time may also be an issue on-site. It is often more efficient to have spares available and to simply remove and tag items that are malfunctioning. These can be dealt with when time is available.

The use of fault-finding checklists is a useful aid to troubleshooting. The following are some examples of fault-finding checklists. Your company procedures may include similar checklists.

EXAMPLE: REGULATOR FAULT FINDING



PROBLEM	PROBABLE CAUSES	REMEDY
Free flowing	1st stage HP seat 2nd stage seat wrong line pressure corrosion dirt	check & replace check & replace re-adjust clean clean
HP leak - 1st stage	o-ring	replace
LP leak - 2nd stage	o-rings on hose & swivel	replace
Hard inhalation	low line pressure corrosion or dirt lack of lubrication	readjust clean and lubricate

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PROBLEM	PROBABLE CAUSES	REMEDY
Hard exhalation	exhaust port perished blocked exhaust tee	replace clear
Water entering - 2nd stage	mouthpiece split diaphragm split or not sealed exhaust port damaged or kinked cracked housing	check, adjust & replace if needed
Weak purge	wrong adjustment lever/purge height incorrect	check line pressure and re-adjust
Erratic air flow	1st stage seat wrong line pressure corrosion in second stage	replace check clean
Air leakage from 1st stage water ports	o-rings worn (around piston) diaphragm not sealing	lubricate or replace tighten

NOTE: All maintenance must be carried out by suitably qualified personnel.

EXAMPLE: PORTABLE COMPRESSOR FAULT FINDING CHECKLIST[12]

PROBLEM	CAUSE	REMEDY
Motor (engine) does not start	see motor (engine) instructions	see motor (engine) instructions
No oil pressure	air trapped in oil pump	vent pump and line - see manual
Oil sight glass exhibits air bubbles	oil pressure regulator dirty	clean and re-adjust oil pressure regulator
Oil foam in the crankcase	3rd stage piston	operate compressor with final valve head removed, if oil flows continuously out of cylinder renew piston and liner
	3rd stage outlet valve defective	replace

12 Courtesy of Bauer Compressors.

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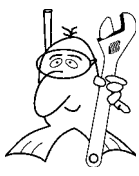
PROBLEM	CAUSE	REMEDY
Compressor does not attain final pressure	condensation in drain valves or fittings leaking	tighten and reseal, replace filter
	premature opening of final safety valve	clean final safety valve and re-adjust
	piston rings worn	replace
	excessive piston clearance	replace
Compressor output insufficient	intake valve clogged	replace cartridge
	pipes not closing properly	re-tighten connections
Safety valves between individual stages releasing pressure	intermediate pressure too high	check valves - see manual
	valves not closing	service and clean valves
Compressor running too hot	insufficient supply of fresh cooling air	check location max ambient temperature + 45°c
	intake or outlet valves not closing properly	check and clean valves, replace worn parts as necessary
	wrong rotation	see arrow on compressor and remedy accordingly
Air has oily taste	improper maintenance of filters, filter cartridge saturated	remedy filters, change filter cartridges
	wrong oil type	use right oil type and clean sooted valves

ON-SITE MAINTENANCE

In general, there is little time or opportunity for on site maintenance. Many organisations have a policy of carrying spares rather than being forced into undertaking on site maintenance by necessity. However, there are some occasions where on site maintenance is necessary – some equipment is simply too expensive to have spares, or there are some maintenance items that are simple and are no problem to perform on site. Some examples of on site maintenance are:



- ✔ air leaks requiring simple o-ring replacement
- ✔ oil leaks on hydraulic tools
- ✔ regulator free flows
- ✔ replacement of torch and video globes
- ✔ repairing the communications system
- ✔ changing a filter or cartridge on a compressor

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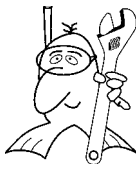
✔ replacing the belt on a compressor

Any on-site maintenance you undertake must be according to manufacturer's instructions. AS/NZS 2299.1 also clearly specifies this. It goes on to say that plant and equipment shall not be altered, modified or changed in any way that might impair the safe and efficient operation of the equipment.[13]

Make sure that whatever on-site maintenance you carry out is well within your capabilities and also that you are following organisational policies and procedures. The same applies to anyone under your supervision. You need to be sure that you are confident that they are following the correct procedures – for this you need to be thoroughly familiar with the equipment and the required procedures.

> **Remember**, if in doubt, don't!

If you are not sure of the correct maintenance procedures for malfunctioning equipment, remove and tag the equipment for repair or maintenance – don't do it on site.



Of course, this advice does not apply to basic requirements for cleaning and storage. It is important to always allow time to properly clean (and disinfect if necessary) all underwater diving equipment, and to dry and store it in an appropriate manner to prevent deterioration, contamination or transmission of disease.[14] This may be on or off-site, but should be done as soon as possible after the dive.

Proper care and maintenance of plant and equipment will prolong its life and enhance safety.

The following is an example of basic maintenance for a regulator. This may be done on-site if necessary. Any major maintenance or repair should be carried out off site in a suitable facility.

EXAMPLE: REGULATOR ON SITE MAINTENANCE

✔ Wash in clean fresh water – pay particular attention to the pressure compensation chamber.

✔ Dry before storage.

✔ Replace the dust cap after the o-ring has been inspected, prior to washing.

✔ Repairs and annual services to be conducted by trained personnel only.

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13 AS/NZS 2299.1:1999, s3.8.1, p 15

14 AS/NZS 2299.1:1999, s3.8.4, p 15

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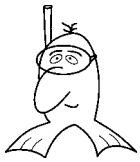
3 CHAPTER 3 – KEEP UP TO DATE

INTRODUCTION

Diving safety has improved immensely due to changes in technology, introduction of new and safer procedures and better knowledge of the physiological effects of working in a high pressure environment. You can only take advantage of these improvements if you know about them!

You need to keep yourself up to date. You can do this by:



- ✔ Knowing sources of information about plant, equipment and procedures applicable to underwater work
- ✔ Using those sources of information to keep your knowledge of plant, equipment and procedures up to date, and
- ✔ Researching new plant, equipment and procedures and evaluating whether they are useful to your organisation.

SOURCES OF INFORMATION

GENERAL

These might include consulting with manufacturers, reading industry journals or magazines, checking information on the internet, talking to others and attending appropriate seminars, conferences or trade shows.

INDUSTRY JOURNALS, MAGAZINES OR WEBSITES

Dive Log Australia		Australian magazine for both commercial and recreational diving
Dive New Zealand;	http://www.divenewzealand.com/	NZ magazine
Diving Trade International;	http://www.divingtradeint.com/	Industry new
Nekton;	http://www.e-nekton.com/	Online Commercial Diver Magazine
Rodale's Scuba Magazine;	http://www.scubadiving.com/	US based recreational mag
Underwater Contractor;	http://www.under-water.co.uk/articles.htm	UK based contractors magazine
Underwater Magazine;	http://diveweb.com/	From the magazine of the same name

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Divers Alert Network	http://www.diversalertnetwork.org/	
Divers Alert Network South East Asia Pacific	http://www.danseap.com.au/	

AUSTRALIAN MANUFACTURERS

For an interesting article on underwater photography equipment, go to http://www.diveweb.com/maritech/features/mayjun2001.01.htm

Australian manufacturers[15] of diving equipment are;

- ✔ Airdive Equipment
- ✔ Alpha Diving Products
- ✔ Aqua Scene
- ✔ Boss
- ✔ Custom Wetsuits
- ✔ Dive Developments
- ✔ Extreme Australia
- ✔ Hot & Dry Drysuits
- ✔ Land and Sea
- ✔ Mirage
- ✔ Neptune Wetsuits
- ✔ Rebel Scuba
- ✔ Sea Hornet Scuba & Spear fishing
- ✔ Seasuits
- ✔ Sonar Wetsuits
- ✔ Sterling

Some international brands include:

- ✔ Aeroskin
- ✔ Beuchat
- ✔ Cressi Sub
- ✔ Dive Rite
- ✔ Drager
- ✔ Extreme Exposure

[15] List obtained from http://www.mantisdive.com.au Mantis Diving

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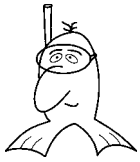
- ✔ Genesis
- ✔ GMC
- ✔ Halcyon
- ✔ Mediving
- ✔ Pelican Products
- ✔ Princeton Tec
- ✔ Sayco Medical
- ✔ Scubapro
- ✔ Tusa
- ✔ Unidive
- ✔ Uwatec

KNOWLEDGE

It is not enough to just read about it or hear about it – you have to actually remember it to be able to add it to your bank of knowledge. You then need to be able to apply it appropriately to your organisation.

Wisdom comes from experience and an ability to apply the experience of others to your situation. You need to make a judgement as to whether the new procedure or equipment is appropriate for your organisation. You may choose not to apply it, if the new procedure or equipment does not suit your organisation or you judge the risk to be unacceptably high. The important thing is to go through the process of assessing the risks and benefits associated with new equipment and procedures – and to revisit that process on a regular basis.



Remember, information is not knowledge, and knowledge is not wisdom!

RESEARCH

There will be times when you will need to actively research new equipment or procedures to achieve a complex task or project.

Again, use the sources of information listed above. This time though, it is likely that you will actually be researching for a specific reason and will need to make a decision on the alternatives available. This means you will need to be thorough in your research, checking all the available options.

You will also need to check the credibility of your information. The internet has vast amounts of information, which is growing every day. The easy access to the internet means that anyone can put up a web page which may look good and appear credible. Be careful though - there may be information that is misleading or downright wrong. Wherever possible, check that the information is from a credible source and get a second opinion from a trusted source.

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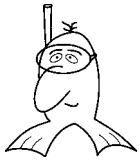
4 CHAPTER 4 – QUALIFICATIONS AND TRAINING

INTRODUCTION

Training is a key factor in maintaining diver safety. As dive supervisor, you are responsible for checking that all personnel have the appropriate qualifications and/or training to use the dive equipment and carry out the required dive procedures.

You will need to:

- ✔ Know the required qualifications and/or training for all specific types of diving,
- ✔ Ensure that qualifications and/or training of all divers under your supervision are adequate and current, and
- ✔ Ensure appropriate training or re-training of personnel when required.



Remember, you are not responsible for actual training – all training should be carried out by a qualified diver trainer.

QUALIFICATIONS AND TRAINING

Most OHS legislation has specific requirements for training, with some legislation actually specifying the required qualifications for certain activities.

■ ADAS QUALIFICATIONS

The ADAS qualifications at the appropriate level are mandatory in Queensland and NSW.

The ADAS qualifications are extensive in their coverage and are nationally and internationally recognised. It is important to understand the difference between the different qualifications, to ensure that the diver is capable and qualified to perform the required task to the required depth.

The ADAS qualifications are known by two names – the traditional ADAS Parts 1, 2, 3 and 4 and the associated restricted qualifications as well as the vocational qualification names. The ADAS courses are accredited under the Australian Qualifications Framework within the Vocational Education and Training system (VET), and the qualifications have equivalent VET names. The Occupational Diving courses are nationally accredited courses and are recorded

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in the National Training Information Service (NTIS) database. The table below gives the ADAS card names and their VET equivalents.

ADAS DIVER QUALIFICATIONS

ADAS Card Name	NTIS National Code	NTIS State Code	VET certificate name
ADAS Part 1	80431	AC00/1391	Certificate III in Occupational Diving (SCUBA Underwater Work to 30m)
ADAS Part 2	80433ACT	AC00/1391	Certificate III in Occupational Diving (Advanced Underwater Work to 30m)
ADAS Part 3	80435ACT	AC00/1391	Certificate III in Occupational Diving (Advanced Underwater Work to 50m)
ADAS Part 1 Aquaculture	80522ACT	AC00/1391	Certificate III in Occupational Diving (Aquaculture Work to 30 Meters)
ADAS Part 2 restricted	80432ACT	AC00/1391	Certificate III in Occupational Diving (Surface Supplied & SCUBA Underwater Work to 30m)
ADAS Part 3 restricted	80434ACT	AC00/1391	Certificate III in Occupational Diving (Surface Supplied Underwater Work to 50m)

ADAS DIVE MEDICAL TECHNICIAN

ADAS DMT	80353ACT	00/1391	Certificate III in Occupational Diving (Diver Medical Technician)

ONSHORE DIVE SUPERVISOR

ADAS Part 1 Onshore Dive Supervisor	80352ACT	AC00/1391	Certificate IV in Occupational Diving (Dive Supervisor - SCUBA Underwater Work to 30m)
ADAS Part 2 Onshore Dive Supervisor	80441ACT	AC00/1391	Certificate IV in Occupational Diving (Diver Supervisor - Advanced Underwater Work to 30m)
ADAS Part 2 restricted Onshore Dive Supervisor	80440ACT	AC00/1391	Certificate IV in Occupational Diving (Diver Supervisor - Surface Supplied & SCUBA Underwater Work to 30m)
ADAS Part 3 Onshore Dive Supervisor	80443ACT	AC00/1391	Certificate IV in Occupational Diving (Dive Supervisor - Advanced Underwater Work to 50m)
ADAS Part 3 restricted Onshore Dive Supervisor	80442ACT	AC00/1391	Certificate IV in Occupational Diving (Dive Supervisor - Surface Supplied Underwater Work to 50m)

ADEQUACY AND CURRENCY OF QUALIFICATIONS AND TRAINING

It is relatively straightforward to check that the accredited qualifications are adequate by checking the competencies in the accredited course, or simply by ringing ADAS.[16]

Checking that they are current is also relatively straightforward, as every diver is required to

[16] Contact details are given in the introduction

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keep a logbook which includes a record of the diving activity undertaken.[17]

It is not as straightforward to check ancillary or incidental training, particularly where a diver moves from job to job with different organisations. You will need to make a judgement as to the extent of checking of training that is necessary for each diver and each skill. You may be able to simply ask the diver whether they have been trained in certain equipment, especially if it is not safety-critical, or where you can readily observe the diver's skills. You may even be able to check with past employers if they have kept records of training.

For safety-critical items, it is best to actually assess the divers' skill before allowing them to use certain equipment or undertake certain tasks or procedures. This may be done as an assessment of knowledge and attitude by asking questions, an assessment of practical skills by direct observation or a combination of these. Alternatively, you may choose to arrange refresher training which can be customised or adjusted to suit the level of skill demonstrated by the diver during the training.

TRAINING OR RE-TRAINING

Part of your responsibilities when preparing for a dive operation is to ensure appropriate training or re-training of divers and support personnel involved in the operation. You need to assess the requirements of the task and the capabilities of the personnel involved. From this assessment, you will be able to determine the training needs for personnel in order to undertake the dive operation safely. You will then need to report on the training needs to management. You may be required to assist in determining the most efficient and cost-effective way to provide the required training.

As dive supervisor, you are not expected to actually provide the training. To provide any accredited technical diver training, you must be an accredited ADAS diver trainer. However, it is common practice for dive supervisors to provide some basic on-site refresher training, particularly for equipment or procedures not often used, or for inexperienced divers.

Make sure that you know what you are doing if you do any refresher training! You need to be thoroughly competent in the use of the equipment or dive procedure yourself if you are providing information to others. Also make sure that you check for understanding. This is best done by asking the diver to summarise the information in their own words or to demonstrate the procedure while you are observing their actions. Don't just say "do you understand?" They may think they do, but then get it wrong. Another problem is that most people don't like looking stupid - it is then tempting to say that they understand, even when unsure.

Keeping training records is good practice and may also be a requirement of the organisation's quality or OHS system. Make sure that the training records are legible, include dates and details of who was trained and what the training covered and if possible, the outcomes of the assessment process.

[17] AS/NZS2299.1:1999, s 2.6.1, p 12

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5 CHAPTER 5 – SUMMARY

PLANT AND EQUIPMENT

- ✔ Know the plant and equipment minimum requirements as specified in AS/NZS 2299.1: 1999 sections 3, 4, 5 and 6.
- ✔ Obtain information on basic function, correct use and maintenance of plant and equipment from the manufacturer's instructions, organisational policy and procedures and in formal accredited training.
- ✔ Some commonly used mixed gases are nitrox, trimix and heliox.
- ✔ Nitrox is a mixture of nitrogen and oxygen, greater than 22% oxygen.
- ✔ Nitrox should not be used below 40msw. Trimix or heliox are used at depths greater than 50 msw.
- ✔ Only carry out troubleshooting and basic on-site maintenance if proper manufacturers and organisational procedures can be followed and there is sufficient time to do the job properly.

- ✔ Remove, label and tag any equipment that has malfunctioned and cannot be maintained on site to make sure it is not used until repaired and checked.
- ✔ Make sure that there is a proper planned maintenance schedule and that maintenance is properly documented.
- ✔ Procedures enhance diver safety. Insist that the dive team follow procedures closely.
- ✔ Keep up to date with new plant, equipment and procedures through reading industry journals, talking to others, attending conferences, seminars and trade shows and using the internet.

DIVING QUALIFICATIONS

- ✔ Diving qualifications specify the depths and tasks that divers have been trained to undertake. ADAS qualifications are nationally and internationally recognised and mandated in the legislation in some Australian States.
- ✔ Qualifications, training and current competency must be checked to ensure that the diver can undertake the dive and the task safely.
- ✔ The dive supervisor should ensure appropriate training or re-training, but is not directly responsible for the actual training (unless accredited as an ADAS diver trainer at the appropriate level). Note that the dive supervisor is still able to provide demonstrations and briefings in the safe use and handling of equipment and methods for refresher purposes, provided the diver is appropriately qualified to undertake the task and use the equipment.

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