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Technical Advisory for Inland/Inshore Commercial Diving Safety and Health



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1. Preface

This Technical Advisory (TA) provides recommendations and guidelines for occupational diving operations and projects. The aim of the TA is to promote safe practice for all occupational diving activities carried out within Singapore inshore and inland boundaries.

The TA is intended for use by companies requiring the services of occupational divers; shipping and vessel owners requiring occupational diving services; diving contractors; diving supervisors; divers and any other personnel who are involved with underwater work.

2. Introduction

2.1 Scope and Application

This Technical Advisory (TA) gives guidance on Good Practice for occupational inshore/inland air diving operations at a depth of up to 50metres of water, and where compressed breathing air is supplied either through surface supplied breathing apparatus (SSBA) or Self Contained Underwater Breathing Apparatus (SCUBA).

Good Practice is termed as that which is reasonably practicable with regards to the planning and implementation of occupational diving operations to make them as safe as possible.

Occupational Inland/Inshore diving operations is defined as operations within the territory of Singapore. Reference definition of "Inland/Inshore" on page 12 under section 2.2.

The guidelines provided in this TA with respect to planning and implementation of occupational diving operations are reasonably practicable measures in ensuring the safety and health of all personnel who are directly or indirectly involved in the occupational diving operation.

Diving contractors are legally responsible for carrying out safe diving operations. The guidelines and information outlined in this TA aim to assist all persons involved in occupational diving operations such as, diving contractors, diving supervisors, clients, support personnel and relevant duty holders who are responsible for complying with the legal requirements under the Work Place Safety and Health Act.

This TA is not intended to be prescriptive in its content; rather, it details the methods by which diving activities should be carried out.

Alternative methods of carrying out diving operations may be used, as long as those methods or techniques comply with legislative requirements and current diving industry Good Practice.

This TA does not provide information on diving activities using oxygen enriched gas mixtures (NITROX) neither is it applicable to recreational diving or training of recreational sports divers, scientific or archaeological diving projects.

Occupational Diving as termed within this TA includes all forms of 'diving for work' conducted within the territorial area of Singapore, with the exceptions of recreational SCUBA/technical diving by instructors/trainers.

Within this TA, the words MUST or SHALL indicates that compliance with a statement is mandatory.

This TA will be updated at regular intervals as set out by the Workplace Safety and Health (WSH) Council. For any recommended or suggested changes all submissions should be sent to the WSH Council for consideration.

Note

Compliance with this TA does not exempt users from legal obligations under the Workplace Safety and Health Act.

2.2 Terms and Definitions

The following definitions and terms shall be found and used in the context of this TA.

Term	Definition
ABS	American Bureau of Shipping (a classification society).
Accident	An unintended event which causes bodily injury to a person.
Acute Illness	An illness characterised by the symptoms having a rapid onset.
ADCI	Association of Diving Contractor International. An American diving contractors association that promotes consensus standards among members, organises training standards and diver's certification.
AGE	Arterial Gas Embolism, is a major cause of death in diving and the initiating cause (pulmonary barotrauma) usually goes undetected. Arterial Gas Embolism, is most often caused by the expansion of respiratory gases during ascent, it can also occur when the breath is held during ascent from a dive.
AODC	Association of Underwater Engineering Contractors (formerly the Association of Offshore Diving Contractors, the abbreviation for which has been retained).
Atmospheric Pressure	The atmosphere exerts a pressure on the earth's surface in the same way as water exerts pressure, i.e. it is produced by the weight of air above the earth.
Absolute Pressure	Before a diver leaves the surface, he is already under a pressure of: 1 Bar or 100,000 N/m ² -(atmospheric pressure). For every metre he descends, the pressure on him will increase by 0.1 Bar. Thus, the total pressure on the diver at any depth will be the pressure of the water at that depth plus atmospheric pressure, 1Bar.
ALARP	As Low As Reasonably Practicable - for a risk to be ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained.
Ambient Pressure	The pressure of the surrounding medium, such as a gas or liquid, which comes into contact with an apparatus or with a reaction.
Audit	A systematic examination to determine whether activities and related results conform to planned arrangements and whether these arrangements are implemented effectively and are suitable for achieving the organisation's policy, the audit may be of a management system, equipment, or a marine vessel.

Term	Definition
BC/BCD	Buoyancy Compensator, Buoyancy Compensator Device – an inflatable harness worn and controlled by the diver, that allows him to achieve neutral buoyancy. This is especially helpful when working on smooth surfaces that do not have handholds for the diver.
Barotrauma	Barotrauma (pressure injury) is a physical damage to body tissues caused by a pressure differential between an air space inside the body and the ambient pressure.
Black Box	A DVD/HDS/VHS or tape recording of the diver's breathing pattern and communications between the diver and diving supervisor. The recording is required to ensure traceability in the event of any incident/accident involving the diver.
Bottom Time	The total elapsed time from when a diver leaves the surface to the time (next whole minute) at which ascent is commenced, measured in minutes.
Bell	A signal used on a lifeline of the diver; the diver to tender or tender to diver makes a short, sharp and fast deliberate pull action on the life line to communicate between each other; Bells are signals that are delivered in pairs; i.e two Bells at a time.
Breathing Gas	The compressed gas intended for respiration by the diver.
Breathing Hose	Hoses attached to a regulator that are designed to supply compressed air from the air source to the diver at low pressure; also known as divers umbilical.
BV	Bureau Veritas (a classification society).
Certification Package	A folder or file that contains signed certificates which show that the diving equipment has been tested and/or checked by competent personnel. In the case of the DDC, the testing will normally be witnessed by a surveyor acting on behalf of a classification society.
Combined Dive	The bottom times of more than one dive, added together and treated as a bottom time for a single dive to the deepest depth for the purpose of determining the divers decompression requirements.
Competent Person	A person who has sufficient experience and training to perform the work required to be carried out and has passed such courses as an accredited organisation may require.
Chronic Illness	A chronic illness is defined as any disease/illness that develops slowly and lasts a long time.

Term	Definition
Classification Society	A non-governmental organisation, often referred to as 'Class'. It establishes and maintains standards for the construction and classification of ships, offshore structures, and PVHO's, and confirms that construction is according to these standards. It carries out regular surveys of items in service to ensure ongoing compliance with these standards.
CSR	Company Site Representative (somebody who oversees the diving project on the clients behalf, to help prevent loss and to maintain contractual integrity for the client).
CVI	Close Visual Inspection (a detailed, recorded inspection of an item, using measuring instruments and tools to validate observations).
DCIEM	Defence and Civil Institute of Environmental Medicine (DCIEM) Diving Tables (Canada).
DDC	Deck Decompression Chamber (a pressure vessel for human occupation, certified by a classification society or other independent body, used for air diver's surface decompression and/or decompression treatment).
Decompression Illness	A common term for acute illness resulting from decompression. This term cover the condition known as decompression sickness (also known as bends) and arterial gas embolism.
Decompression Table	A specific table of pre determined depths and times used to calculate the decompression requirements for a particular dive.
Decompression Schedule	A specific decompression procedure for a given combination of depth and bottom time as listed in a decompression table. It is normally described as maximum depth (m)/bottom time (min).
Decompression Sickness (Bends)	The development, during or after diving, of any abnormality which is a direct result of a reduction in the pressure of inert gases dissolved in the body, with the production of gas bubbles. Any organ may be involved and its presentation can vary from the acute to the chronic. (Note: It is common for decompression sickness to show up before or very soon after completion of the dive).
Decompression Stop	The specific length of time that a diver must hold his ascent at a specified depth to allow for the elimination of sufficient inert gas from the body to allow a safe ascent to the next decompression stop or the surface.
Demand Gas Supply Device	A device that provides breathing gas to the diver via a mechanism which provides a flow of breathing gas when the diver inhales (also known as a regulator).

Term	Definition
Depth Gauge	When used to indicate the depth of a dive means the maximum depth attained during the dive, measured in either feet of seawater or metres of seawater.
Diving Operation	A diving operation identified in the diving project plan.
Dive Control Position	A single, designated location on the surface, adjacent to/ or near by where a diver enters the water, from which it is possible to monitor all systems and functions which relate to the life support of a diver in the water.
Dive Team	The group of people, including the diving supervisor, diver(s), attendant(s), and other personnel as required, who are: <ul style="list-style-type: none"> • Present at the dive site; • Directly involved in the dive; and • Responsible for the safe conduct of the diving operation.
Diver	A person who performs diving work underwater or is exposed to pressure greater than 100 millibars above atmospheric pressure in association with diving work.
Divers Umbilical	Umbilical used in SSDE to carry breathing air to the diver from a remote location, including hard wire communications and possibly cables for hat camera and light.
Diving Contractor	Employer of diving supervisor, diver, or other personnel who provides supporting services for the diving operation and includes freelance divers. The diving contractor is responsible for the safety of the diving project.
Diving Helmet	A helmet that: <ul style="list-style-type: none"> • Is constructed of rigid material; • Encloses the entire head area and keeps it dry; • Incorporates an integral breathing system; and • Provides a hard wire/verbal communications system.
Diving Work	Work in which diving is conducted using underwater breathing apparatus, including work by the dive team in direct support of the diver.
Diving Supervisor	A person who is appointed in writing by the diving contractor to supervise the diving operation. He is responsible for the safety of the diver during any dive operation.
DMT	Diver Medical Technician (a person who has received specialist medical training in the identification and treatment of diving illnesses, who is normally also a trained diver).
DMAC	Diving Medical Advisory Committee (an independent European based health committee that advises on diving health and safety).

Term	Definition
DnV	Det Norsk Veritas (a classification society)
DPP	Diving Project Plan; a detailed listing of all of the elements, actions and activities that make up the diving project-sometimes referred to as a Dive Plan (DP).
Diving Project	An activity made up of one or more diving operations. A term used for the overall diving job. The diving project is made up of one or more diving operations.
DOM	Diving Operations Manual – the diving contractors manual that specifies how he carries out his diving operations-reference Annex G.
DSV	Diving Support Vessel.
DUI	Detailed Underwater Inspection.
ERP	Emergency Response Plan.
Exceptional Exposure Dive	A dive where the maximum recommended dive time for a particular depth (sometimes shown by a limiting line in decompression tables) is exceeded by the diver at that depth.
Float Line	A line connecting the diver to a high visibility float on the surface of the water enabling the approximate location of the diver to be known at all times.
FRC	Fast Rescue Craft.
Free-flow System	A breathing method used in SSBA diving operations whereby the breathing gas enters the full-face mask or incompressible helmet in a continuous flow and is not controlled by a demand gas supply device.
FSW	Feet of sea water (a measurement of water depth).
Full- face Mask (Band Mask)	A face mask that: <ul style="list-style-type: none"> • Is constructed in a single unit; • Encloses the total area of the face; and • Incorporates an integral breathing system.
Gauge Pressure	A pressure gauge is normally graduated to read 'Zero' when the gauge is at atmospheric pressure. This is because a pressure gauge normally records only 'difference of pressure'; i.e. the difference between that of a high-pressure source and atmospheric pressure.

Term	Definition
GVI	General Visual Inspection – a recorded inspection of an item, normally looking for gross damage or deformation.
Half- face Mask	A mask that covers the eyes and nose only and does not incorporate an integral breathing system. (Not recommended for use in occupational diving activities outlined in this TA.)
Hazard	Anything or any source or situation with the potential to cause harm or injury.
Hazard Identification	Process of recognising that a hazard exists and defining its characteristics.
HPU	Hydraulic Power Unit.
HS & E	Health, Safety and Environment.
IDSA	International Diving Schools Association. Formed in 1982 to promote commercial diving education standards.
IMCA	International Marine Contractors Association, the international trade association representing offshore, marine and underwater engineering companies. It promotes good practice, particularly in the areas of health, safety and environmental standards, quality and efficiency and technical standards, through the publication of activity specific manuals, guidelines, safety flashes, audit documents, etc.
IMS	Integrated Management System.
Inshore/Inland Diving	Inside territorial waters (normally within 12 nautical miles from shore), including docks, harbours, anchorage, canals, culverts, rivers, estuaries, lakes, reservoirs, dams, flooded tunnels and tanks.
Incident	An event that gave rise to an accident, or has the potential to lead to an accident.
JHA	Job Hazard Analysis, a safety management tool that can be used to define and control the hazards associated with a job or procedure.
LARS	Launch and Recovery System - a means of the diver accessing and exiting from the water in a safe and controlled manner.
Lazy Shot	A free-hanging rope, running vertically from the dive control position to an attached weight positioned off the bottom or worksite.
Lifeline	A line attached to a diver, which is capable of being used to haul the diver to the surface. It can also be used for Diver/Tender signalling.

Term	Definition
Limiting Line	A line shown in some decompression tables which indicates time limits (bottom times) beyond which the use of the decompression schedule is less safe.
LR	Lloyds Register (a classification society)
MOM	Ministry of Manpower (Singapore).
Must	Indicates what is required to complete the task, action or procedure and that compliance with the statement is mandatory.
MSDS	Material Safety Data Sheet, also known as Safety Data Sheet. Contains product information, along with safe means of handling, storage, disposal, hazards, exposure controls and first aid treatment.
MSW	Metres of Sea Water (a measurement of water depth).
NDT	Non Destructive Testing.
NEA	National Environmental Agency (Singapore).
No Decompression Limits	The maximum time which can be spent at a given depth such that a safe ascent can be made directly to the surface at a prescribed rate with no decompression stops.
OGP	Oil and Gas Producers.
Oxygen	Any gas or mixture of gases with 25% oxygen or more.
Personal through-water communications	Battery powered communications systems usually used by recreational divers to talk to each other. Not commonly used for commercial diving operations.
Personal Locator Beacon	PLB (i.e. a compact personal location device) robust enough for professional use and has a depth rating of a minimum of 70 metres (195 feet). The PLB is lightweight (600g/1lb 3oz).
PMS	Planned Maintenance System – a systematic, recorded and verifiable equipment maintenance regime, carried out by a competent person, to ensure that plant and equipment used in diving operations is properly maintained in accordance with the manufacturers recommendations, in order to ensure that it is safe while being used.
PPE	Personal Protective Equipment.
PTW	Permit To Work.
Pull	a signal used on a lifeline of the diver; the diver to tender or tender to diver makes a slow, deliberate pull action on the life line to gain attention or communicate between each other

Term	Definition
Quick Release Mechanism	A readily operated mechanism that enable the immediate release (e.g. of diver's equipment) from the secured position by a single operation of one hand, but which is designed to minimise the risk of accidental release.
Repetitive Dive	Any dive conducted within 12 hours of a previous dive.
Residual Nitrogen Risk	Nitrogen gas that is still dissolved in a diver's tissues after surfacing. A risk is the possibility that someone or something will be harmed by an identified hazard. The extent of the risk includes the number of people who might be affected by the risk.
Risk Assessment	The process of estimating the magnitude of risk and an evaluation of precautions that can be taken to prevent harm and deciding whether or not the level of risk is tolerable.
ROV	Remotely Operated Vehicle.
SCUBA	Self-Contained Underwater Breathing Apparatus. Open circuit diving equipment that supplies the diver with breathing gas from the cylinder(s) carried by the diver.
Shall	Indicates that compliance with a statement is mandatory.
Shot Rope	A rope running vertically from the dive control position and fixed to the worksite or bottom with a weight or attachment.
Should	Indicates a recommendation.
SMS	Safety Management System.
SSBE	Surface Supplied Breathing Equipment. Diving equipment that supplies breathing gas at the required pressure for depth, through a diver's hose to a diver from plant at the surface. May be also termed as SSBA – Surface Supplied Breathing Apparatus.
Stand by Diver	A diver fully dressed and equipped to enable immediate entry into the water to provide aid or assistance to the working diver.
SWL	Safe Working Load, the maximum load that can be safely lifted. This term is being replaced with WLL (see below).
TA	Technical Advisory (this document).
Tolerable Risk	Risk that has been reduced to a level that can be endured by the organisation having regard to its legal obligations and its own OH and S Policy.
Toolbox Talk	A meeting, to ensure that everyone clearly understands what the job entails along with its hazards and the precautions to be put in place.

Term	Definition
WLL	The Working Load Limit (WLL) is the maximum load that may routinely be applied to an assembly or component in straight tension.
WSH Council	Workplace Safety and Health Council - The Workplace Safety and Health (WSH) Council was established on 1 April 2008. The Council works closely with the Ministry of Manpower and other Government agencies, industry, unions and professional associations to develop strategies to raise WSH standards in Singapore and to realise the national WSH 2018 strategy.

3. Hazards in Commercial Diving Work

3.1 Environmental Hazards

This section discusses environmental and physiological hazards that **SHALL** be considered when planning any diving operation.

3.1.1 Currents, Tides, Tidal Range and Slack Water

Currents

Currents are flowing masses of water within a body of water and can be divided into the following groups: major ocean currents; tidal currents (tides are periodic rises and falls of large bodies of water).

Tides

Tides are caused by the gravitational interaction between the Earth and the Moon, (which may increase or reduce existing currents); rip currents; river currents in the proximity of an estuary.

The direction and speed of a current varies with water depth, tide and bottom contour. Current readings near the surface may not reflect the actual speed and direction of a current in deeper water.

Tidal Range

This is the difference between the high tide and the low tide in one day. This range will be different every day and can be found by looking in the local tide tables.

- Spring Tide occurs when the gravitational pull of the moon and sun is either in opposition or conjunction. These happen alternately every two weeks and will be highest high water and lowest low water period
- Neap Tide is when the moon and the sun are at right angles to the earth. These happen about every fortnight in between the spring tides. Neap Tides result in less extreme tidal conditions.

Slack Water

Slack water is when there is a period of no water movement when the tide has reached the highest tide or lowest tide. At slack water - the tide has reached the lowest point and there will be a period of time of no or limited water movement prior to the water beginning to flood to reach the highest point at the slack water high and another period of no or limited water movement will occur before the ebbing to the lowest point. This will occur alternately. Tide tables are produced to enable an assessment of what the tide is doing each day. The period of time of slack water varies with location.

3.1.1.1 Effects of Currents on Divers

The effects of currents on divers varies with the individual, the work being done and the diving method used. Currents produce forces which affect not only the diver's body but also his umbilical/lifeline, together with the various lines and pieces of equipment he may have at the work depth. A proportion of the diver's energy is thus devoted to overcoming these forces until the point is reached when he will eventually become unproductive. As an increasing amount of energy is devoted to combating the effects of current as well as carrying out productive operations, it follows that the greater the speed of the current, the shorter will be the period during which the diver will be effective before the onset of significant fatigue.

How much current, or force, a diver can withstand and still continue to work effectively depends on various factors:

- Individual physical strength and endurance to fatigue;
- Type of equipment being used;
- Length of umbilical, its deployment either vertical or horizontal, orientation in the current, and whether floating or negatively buoyant;
- Whether the work is being carried out on the seabed or in mid-water;
- The type of work being carried out and the tools used to do it;
- Whether the use of both hands is required to perform a task;
- Current fluctuation and changes of direction; and
- The ability of the standby diver to go to the aid of the diver in the event of an emergency.

In Table 1 below, workplace experience and anecdotal evidence have been evaluated in order to:

- Indicate the increasing restrictions placed on diving operations by increasing current strength;
- Facilitate identification of certain conditions beyond which it would be unwise to continue diving; and
- Operate on a purely routine basis.

It must be appreciated, however, that it is impractical to be definitive in identifying the restrictions imposed by certain current conditions since these are affected by so many variable factors. The values in the tables below should, therefore, be applied with a degree of flexibility taking account of diver feedback.

SCUBA Diving Methods With Use of A Lifeline

Location in water	Current (knots)	0.0 to 0.8 kts	0.8 to 1.0 kts	1.0 to 1.2 kts	1.2 to 1.5 kts	1.5 to 2.0 kts and beyond
Mid-Water Work		Normal Work	**NB1	**NB2	Diving operations not permitted	
Bottom Work		Normal Work	**NB1	**NB2	Diving operations not permitted	

Surface Supplied Diving Equipment Diving Methods

Location in water	Current (knots)	0.0 to 0.8 kts	0.8 to 1.0 kts	1.0 to 1.2 kts	1.2 to 1.5 kts	1.5 to 2.0 kts and beyond
Mid-Water Work		Normal Work	Observation	**NB1	**NB2	
Bottom Work		Normal Work	Light Work	Observation	**NB1	**NB2

Table 1: Working Recommendations in Currents.

**NB 1 – Diving by means of this method in these currents should not be a routine operation. The Diving Supervisor should consult with the divers involved and any other person he judges necessary about the best way to conduct such an operation.

**NB 2 – Diving by means of this method in these currents should not be considered unless the operation has been pre-planned taking account of the presence of high current from the early stages of the project. Special solutions involving equipment techniques and procedures should have been evolved to overcome – or protect the diver from – the effects of currents and to provide contingencies for foreseeable emergencies.

3.1.2 Contaminated Water Diving

Water in inland/inshore locations always carries the risk of contamination from industrial, agricultural or domestic pollutants, or foreign bodies.

The initial risk assessment for the diving project must consider the possibility of contamination, and it is the responsibility of the client to inform the diving contractor of the presence of contaminants in the water, or the likelihood of contaminants being in the water. When the water in the diving location is suspected of being contaminated the water should be tested/checked for harmful pollutants by a competent person or organisation. Water odour, colour, appearance and the location of factories or outfalls may give some indication of the presence of pollutants.

Low level water contamination, such as that found in most harbors, is best addressed by ensuring that the water is unable to enter the diver's airway. Full facemasks/helmets and disposable oversuits (similar to the type painters use) are normally sufficient to prevent diver contamination. In cases where the contaminants are evident and diving is to take place; equipment used shall provide 100% assurance that the diver will be protected from the hazardous material. Such occasions when diving may be required are:

- In mud or waters which have been contaminated by chemicals, effluents, hydrocarbons or similar hazardous substances;
- In sewage systems;
- At or near discharge systems of platforms, rigs or ships; and
- At or near outfalls from power plants.

All requirements to carry out diving operations in contaminated water will need to be assessed on an individual basis.

Note

Diving with or near radio active materials will require specialist advice which should be sourced from the National Environmental Agency and reference should be made to Radiation Protection Act 2007 (Act 27 Of 2007).

3.1.3 Restricted Surface Visibility

Restricted surface visibility caused by, for example, heavy rain or fog may affect the safety of the operation. The diving project plan will need to identify when operations will need to be suspended because of restricted visibility. When surface visibility is substantially reduced, due to fog or mist, diving **MUST** stop for safety reasons. On some occasions these reasons are not fully understood (the "it is not foggy underwater" approach), whilst on others, diving supervisors are unsure of the parameters to apply in making their decision.

Surface orientated divers, in an emergency, may make their way to the surface, or alternatively, their umbilicals may have been severed by accident. SCUBA divers may be cast adrift from their work location and surface to find out their location.

Once on the surface, and possibly injured or unconscious, they must be rescued, therefore visibility should be sufficient to allow for their speedy location and recovery. Lights carried by such divers, to allow them to be located on the surface, cannot be guaranteed to perform the same function in a fog or mist.

Poor surface visibility may seriously affect diving operations. As with most diving safety requirements it is a matter of judgment by the diving supervisor on site, to decide when diving should stop due to reduced surface visibility.

3.1.4 Restricted Underwater Visibility

Poor seabed visibility can alter the effectiveness of the diving operation. Diving operations near or on the bottom can stir up fine grained sediment which may reduce visibility, particularly in low or zero current situations.

3.1.5 Sea State

The sea state can affect every stage of a diving operation. Working from a support vessel/floating structure in rough seas requires a careful consideration of personnel safety before and during any dive boat launch and recovery. Rough seas also require a heightened awareness of the possibility of accidents during diver recovery, both to the surface crew and to the divers. As with most diving safety requirements it is a matter of judgment by the diving supervisor onsite, to decide when diving should stop due to an adverse sea state.

Reference Annex P- Mariners Sea State Chart Beaufort Scale.

3.1.6 Weather

The cost and efficiency of operations can be adversely altered by the effects of weather. Local weather forecasts should be consulted before commencing any diving operation, and forecasts should be included within the dive plan.

While divers under water may not be directly affected by the various effects of weather, these can have an effect on diving operations in a number of different ways:

- Wind speed and direction can make station-keeping difficult for the support vessel/floating structure;
- Rain and fog will cause a reduction in surface visibility, possibly creating a hazard for the support vessel/floating structure;
- Bad weather can make working on deck extremely hazardous for the diving crew, particularly with adverse combinations of wind, rain, etc.;
- Hot weather can cause overheating. In particular umbilicals stored on deck are more susceptible to overheating by warm air or direct sunlight;

- Extreme heat, including direct sunlight, can cause the temperature inside deck chambers to rise to dangerous levels. In such conditions the internal temperature should be monitored and kept at a comfortable level;
- Extreme heat, including direct sunlight, can adversely affect divers acting as standby divers who will be static but dressed in most of their diving equipment. Arrangements should be made to keep the standby diver sheltered, at a comfortable temperature and well hydrated; and
- Electric storms or lightning may be a hazard to exposed personnel or equipment.

Diving activities **SHALL** be suspended during inclement environmental conditions.

Reference Annex P- Mariners Sea State Chart Beaufort Scale.

3.1.7 Marine Animals

The list of marine animals that are potentially dangerous to divers is extensive, and examples include fire coral, jellyfish, invertebrates such as blue ringed octopus, stonefish, sea snakes etc.

Divers **SHALL** wear suitable protective clothing that may include but is not limited to the items outlined in paragraph 5.2.7. The protective clothing should be robust enough to give protection from accidental contact.

The First Aid Kit onsite should include suitable treatment creams and solutions for treating venomous/stings from marine animals. Local medical centers should be included in the ERP for treatment of such cases.

The type of dangerous marine animals that may be found at the dive location should be ascertained before diving operations commence. The risks and treatment if contact is made with those dangerous marine animals should be included in the project risk assessment and dive plan.

3.2 Operational Hazards

3.2.1 Water Intakes and Discharges

Divers are vulnerable to suction or turbulence caused by water intakes and discharges as well as discharge products. The diving contractor will need to establish with the client whether there are any underwater obstructions or hazards in the vicinity of the proposed diving project. If there are any intakes or discharges, suitable measures need to be taken to ensure that these cannot operate while divers are in the water unless the divers are protected with a suitable physical guard. Such measures need to be part of a work control system, such as a permit-to-work system, and could include mechanical isolation.

3.2.2 Differentials in Pressure

One of the major causes of diving accidents is the pressure differential that may exist between the water pressure on the two sides of a barrier. The barrier may be, but is not limited to a dam, pipeline, flange, sluice gate, coffer dam or other structure. When there is low pressure on one side and high pressure on the other, the possibility of an accident is increased. There have been numerous incidents where divers have been pinned against suction intakes, lost limbs, or suffered other serious injuries due to pressure differentials. This has been recorded as having occurred and caused fatalities in water as shallow as 1.5m depth, such as a swimming pool.

Whenever a dive is planned within areas of known or suspected pressure differentials or equipment such as intakes, or exhausts etc. – the risk assessment and planning **MUST** include specific input with regards to isolations and barriers. Whenever possible a double barrier should be applied. Failure to recognise this type of hazard can be fatal.

3.2.3 Lost Diver

The possibility of a diver becoming lost is completely unacceptable, and the pre-dive risk assessment must explore this possibility, and rigorously challenge the diving procedure to minimise the risk of any diver becoming lost.

In the event that SCUBA equipment is used for the working diver and standby diver, the equipment **SHALL** also include as a minimum, a lifeline (surface supplied divers have an umbilical that acts as a lifeline), a full face mask and communications with the diving supervisor. The diver **SHALL** also be fitted with a suitable personal location beacon that can be interrogated by the locator device onboard the dive vessel and/or emergency services.

Where a scuba diver is deemed to be “lost”, the diving supervisor shall initiate the emergency response procedure.

3.2.4 Confined Space/Overhead Environment

An underwater confined space is any underwater situation in which there is an “overhead environment” obstructing direct vertical access to the open water surface. Underwater confined spaces also may exhibit the characteristics of other confined spaces such as limited number or size of openings for entry and exit.

The following examples are typical underwater confined space diving situations:

- Sewer line installation, repair and maintenance;
- Ship yard diving during docking activities;
- Ship hull cleaning activities;
- Irrigation siphon repair, maintenance, and debris removal;
- Underwater dredging and construction activities which involve an overhead environment with limited direct access to the water’s surface; and
- Recovery and rescue operations (which can be necessary in the above situations).

During such diving operations confined space entry requirements **MUST** be detailed in the dive planning.

Some hazards associated with underwater confined space diving are:

- Because underwater confined spaces contain many unique dive hazards, confined space diving requires specialised training. A primary hazard is the existence of a “ceiling” which restricts direct access to the surface, requiring the diver to be completely dependent upon properly functioning equipment. Should an emergency occur, the diver cannot make a free ascent to the surface. Many divers, unaware of the consequence of having a ceiling, fail to plan for such an emergency.
- Other hazards associated with the confined space “ceiling” include the fact that normal requirements for air reserves are inadequate. It often takes more air to exit a confined space than it takes to enter. Additionally, any kind of labour intensive diving requires much more air. It is also imperative that divers be aware of elevation changes in confined space dives. Deeper dives result in increased air volume requirements due to increases in pressure. Yet another frequently unrecognised confined space diving hazard is disorientation. Divers in confined spaces can easily lose sight of landmarks and thereby lose direction. This can cause confusion and ultimately lead to panic.

Some safety recommendations to be considered when conducting confined space diving are:

- Ensure that the dive operation is necessary and that all alternatives have been considered;
- Prepare a dive plan;
- Accurately calculate air supply with special attention to elevation changes, i.e. pressure changes during the dive which can increase air requirements;
- Tether and tend all divers in the water;
- Utilise open circuit SCUBA only after all other alternatives (such as surface supplied air) have been exhausted;
- Utilise communication and retrieval systems that can be operated from the surface;
- Use DIN fitting first stage regulators on emergency bailout cylinders and/or SCUBA cylinders;
- Implement a permit-required confined space entry programme with formal training and practice;
- Tend the diver who is entering the confined space/over head environment from the entry point. This may require a diver/in water tender; and
- Carryout an emergency diver recovery exercise at the start of the diving operations to familiarise all team members with the emergency requirements.

3.2.5 Entanglement/Entrapment

Entanglement of divers’ lifeline and/or umbilical can occur if not suitably managed. It shall be the divers’ responsibility to check on a regular basis during the dive that his lifeline/umbilical is free from entanglement and clear to the surface. This can be carried out by using line signals between the diver and tender to ensure the tender can ‘feel’ the diver moving at the end of the umbilical line. Management of the umbilical line by the tender is carried out by ensuring only the amount the diver requires to work at the job site is provided and any excess is retained on deck.

The diving supervisor should also ask the diver to check that his umbilical is free and clear on a regular basis during the dive and particularly during any critical activities such as lowering of objects to the diver using a crane.

In the event the diver becomes entangled or trapped. The diver should try to free himself while the diving supervisor should activate the standby diver if required.

Reference Underwater Emergency Procedures- Entanglement paragraph 13.2

3.3 Physiological Hazards

3.3.1 Drowning

Drowning is death from suffocation (asphyxia) caused by a liquid entering the lungs and preventing the absorption of oxygen leading to cerebral hypoxia and cardiac arrest.

There are many factors that can lead to drowning, however, for divers, it is likely to be the result if the diver panics (for whatever reason), or as a result of equipment failure, or the if the diver's breathing apparatus becomes detached. It should be noted that it is very rare for commercial divers, using SSBE and full face masks/dive helmets, to drown.

Drowning is more common for a SCUBA diver if he becomes entangled and is unable to free himself before his air supply fails. There are numerous incidents of SCUBA divers drowning after becoming entangled, not monitoring their air supply or other such causes.

There are three types of drowning which are:-

- Wet drowning;
- Dry drowning; and
- Secondary drowning.

A person with water in his lungs may not lose consciousness immediately, but may still die later from 'secondary drowning' due to pulmonary oedema resulting from a reaction to the inhalation of either fresh or salt water.

All suspected near drowning victims should be observed in hospital for 24 hours.

3.3.2 Thermal Exposure

Thermal exposure can relate to either a hot or cold environment. Hypothermia means a lowering of the body temperature and hyperthermia means raising the body temperature

Normal body core temperature is 37°C. The human body is homeothermic, (warm blooded), and must constantly interact with its external environment in an effort to maintain thermal equilibrium. The human body basically operates in a very narrow temperature range. Slight cooling of the body, 36°C can produce discomfort, and continued cooling can cause serious, if not life threatening physiological changes. The table below shows the approximate core body temperature and the expected symptoms related to the temperature.

Approximate Core Temperatures	Symptoms
37°C	Normal body temperature.
36°C	Increased metabolic rate. Uncontrollable shivering (in most people).
34°C	Impaired judgment. Slurred speech.
31°C	Shivering decreases and is replaced by muscular rigidity. Movement becomes erratic and jerky.
28°C	Irrational behavior. Stupor. Muscular rigidity. Pulse and respiration slowed.
27°C	Unconsciousness. Loss of reflexes. Fixed and dilated pupils. Low or undetectable pulse. Ventricular fibrillation may occur.
25°C	Failure of cardiac and respiratory centres. Ventricular fibrillation. Death.

Table 2: Body Temperature and Hypothermia Symptoms; Approximate Core Body Temperature and the Expected Symptoms Related to the Temperature.

Wet suits can also be worn to maintain body temperature, however, wet suits lose their effectiveness with depth and should not be used for dives exceeding 30m (90fsw). Wetsuits are made of neoprene, (between 3mm and 7mm thickness), which is a porous material containing literally millions of tiny bubbles. This material is an excellent insulator because it places a barrier of air, in the form of the nitrogen bubbles, between the body and the surrounding water. A thin layer of water will enter and it is quickly warmed to body temperature. As the dive gets deeper the neoprene compresses against itself, which makes the suit become looser, making it easier for any water that did enter the wetsuit to leak out. Generally, wet suits are suited to short term exposures, where the water temperature is above 12°C. The wet suit also acts as a form of Personal Protection Equipment by providing a barrier to the skin and body soft tissues.

A dry suit may be used for diving operations that require additional thermal protection and where the water is contaminated (Reference contaminated water diving para 3.1.2). The purpose of the dry suit is simply to keep the diver dry and by doing so the diver is also protected from any contamination in the water. The garment worn under the suit, commonly referred to as “wooly bear” is what is responsible for keeping the diver warm. The warmth is a function of the ability of the material to trap and hold air between the fibers. If dry suits are worn for diving operations, the diver **MUST** be familiar with and trained in the use of such suits. This is because dry suits are normally fitted with suit inflation, and the diver is required to understand the consequences of inappropriate use of the suit inflation mechanism.

The same thermal problems are true if the body is heated. Overheating can lead to heat exhaustion and heat stroke.

Heat exhaustion is a mild form of heat-related illness that can develop after several days of exposure to high temperatures and inadequate or unbalanced replacement of fluids.

Heat stroke is an abnormally elevated body temperature with accompanying physical and neurological symptoms. Unlike heat cramps and heat exhaustion, two forms of hyperthermia

that are less severe, heat stroke is a true medical emergency that can be fatal if not properly and promptly treated.

Most divers associate cold stress and hypothermia with polar or temperate region waters and fail to recognise the “thermal drain” that can be associated with diving in the tropics.

Diving in tropical areas may expose a diver to heat stress both in and out of the water. Pre-dive heat exposure may lead to significant dehydration putting the diver at risk once he enters the water. This is especially true if a protective suit has to be worn because of marine life or contamination. Specific guidelines based on temperature/time exposures are not available but hyperthermia should be considered a potential risk any time the air temperature exceeds 90°F (32°C) and the water temperature is above 82°F (27°C).

Either cold stress or heat stress problems should be anticipated by the dive team and measures to minimise these stress effects must be covered by the pre-dive planning and Risk Assessment.

3.3.3 Decompression Illness (DCI)

Decompression illness, or DCI, is a term used to describe illness that results from a reduction in the ambient pressure surrounding a body, and the formation of bubbles within the body system(s).

DCI encompasses two diseases, Decompression Sickness (DCS) and Arterial Gas Embolism (AGE). DCS describes a condition arising from the precipitation of dissolved gases into bubbles inside the body on de-pressurisation. The bubbles grow in the body tissues causing local damage.

AGE results from bubbles entering the lung and circulation system, travelling through the arteries and capillaries and causing tissue damage by blocking blood flow at the small vessel level, (in the central nervous system – brain).

Decompression Illness is usually experienced by divers, but it is not limited to diving in water. Any person exposed to pressure changes (such as, aviators, astronauts and compressed-air workers) may be at risk of decompression illness.

At sea level, air is composed of approximately 79% nitrogen which is an inert gas. The pressure exerted by the water on the air in the body compresses the air and makes it denser so that as the diver descends the body tissues will absorb more nitrogen with each breathe.

The lungs can eliminate the inert gas through the respiration process, however this is not sufficient to remove all the inert gas build up so the nitrogen starts to accumulate in the blood and body tissues in proportion to the surrounding pressure (like adding carbon dioxide to soft drinks and sealing the can).

As long as the diver remains at pressure the nitrogen remains absorbed in the blood and body tissues. However, if the body is subjected to a loss of ambient pressure (such as rapid ascent - like shaking and opening a can of soda, or ascending without consideration for decompression stops) the nitrogen will expand into bubbles (come out of solution) faster than it can be exhaled by the lungs (the example of this is the formation of bubbles when a can or bottle of pressurized soft drink is open).

If the bubbles form in or near joints, this will cause joint pains which contribute to the decompression illness, commonly known as “bends”. Because nitrogen is absorbed so efficiently by the central nervous system, it can commonly result in an injury that appears spinal in nature, and which may lead to paralysis . The bubbles in the blood may form in any part of the body, as the nitrogen (inert gas) is absorbed in different tissues at different concentrations. For example, fatty tissue absorbs nitrogen at a much faster rate than muscle or bone tissue, but that fatty tissue also off-gasses the nitrogen at a much faster rate. The different concentrations of nitrogen in the different tissues explain why symptoms may not occur until the diver has been on the surface for a period of time. Where DCI can show symptoms during ascent or immediately after a dive, it is also possible for the symptoms to manifest and become evident up to 12 hours on completion of the dive. Delayed onset is rare, but it does happen.

Numbness, pain, shortness of breath, paralysis and disorders of higher cerebral function may also occur as the bubble from the various tissues and in the central nervous system increase in size.

Aetiology of Decompression Illness

The simplistic view of decompression illness is that as divers breathe gas at ambient pressure the tissues become saturated with gas at that pressure. When the ambient pressure is decreased, gas bubbles form, and results in decompression illness.

However, a large number of factors affect the amount of gas in a tissue for a given pressure and exposure:

- The gas
- Blood supply
- Tissue type

The Gas

For instance, helium diffuses in and out of tissues faster than nitrogen.

Blood Supply

The greater the blood supply to a tissue, the greater the amount of gas arriving at the tissue in unit time, and hence the more it can take up in unit time. The brain has a large blood supply, and bone a small one.

Tissue Type

Gases are more soluble in certain tissues, e.g. the brain, fat and less so in bone. Thus, the tissues are differently affected by different types of dive. For instance, a deep short dive will tend to saturate the fast tissues, but not the slow ones. Conversely, a long shallow dive will saturate both kinds of tissues. Thus, rapid decompression in the first case would be expected to produce decompression illness in the fast tissues, and in the second case in both tissue types.

Factors Increasing The Chance Of Getting Decompression Illness

- Work
- Age, 40+ increased risk
- Fat, high solubility, poor blood supply
- Blood, surface tension decreased by alcohol increased bends
- Increased CO₂ in helmets lead to bigger and better bubbles
- Exercising during decompression leads to increased bends
- Changing gas mixtures

Decompression Illness Type

There are two types of decompression illness – primarily known as Type 1 and Type 2.

The following table is a guide to recognising the many forms that decompression illness may take, however the symptoms should be described in their full capacity. Type 1 is represented by joint pains and rashes which are defined as 'mild'. Type 2 is serious and dangerous, usually involving either the central nervous system or pulmonary effects, such as air embolism. It should be noted that Type 1 symptoms may be 'masking' the more serious Type 2 decompression illness.

Symptoms Of Decompression Illness Observation Chart

Symptoms	Type	Common and / or Technical Name	Urgency	Action
Discomfort, or slight pain in a limb	1	Niggle	Vigilance	Observe. Possibly recompress.
Rash; itching	1	Skin Bend; Pruritis; Mild Decompression Sickness	Vigilance	Observe. Possibly recompress.
Deep pain in joint	1	Bend; Hit; Decompression Sickness	Urgent	Recompress.
Localised soft swelling	1	Oedema; Lymphatic Bend; Lymphatic Decompression Sickness	Vigilance	May need recompression.
Swelling in neck with crackling under skin	1	Interstitial Emphysema Surgical Emphysema	Non Urgent	Observe. Possibly recompress

continued...

Symptoms Of Decompression Illness Observation Chart

Symptoms	Type	Common and / or Technical Name	Urgency	Action
Pins and needles; "wooliness" of feet	2	Bend; Spinal Bend; Serious Decompression Sickness	Very Urgent	Recompress. Consult nearest diving doctor
Excessive tiredness; general "unwellness"	2	Bend; Decompression Sickness	Very Urgent	Probably recompress. Consult nearest diving doctor.
Unconsciousness; headache; difficulty with vision or speech	2	Bend; Cerebral Bend; Serious Decompression Sickness; Air Embolism	Extremely Urgent	Recompress. Send for nearest diving doctor.
Unsteadiness; dizziness; nausea; vomiting	2	Staggers; Cerebral Bend; Vestibular Bend; Vestibular Hit; Vertigo; Serious Decompression Sickness	Extremely Urgent	Recompress. Send for nearest diving doctor.
Pain in chest; breathing difficulty; shortness of breath; coughing; blue colour	2	Pneumothorax; Chokes	Extremely Urgent	Give O ₂ . Recompress for chokes only. Send for nearest diving doctor.

Table 3: Signs and Symptoms of Decompression Illness.

Treatment of Decompression Illness

Apply pressure, and the bubble decreases in size, and the symptoms disappear. The tables used for treating decompression illness are therapeutic tables, and are of two types – air and oxygen. Which table to use is decided on by the type of decompression illness and the severity.

Any abnormal signs or symptoms exhibited by a diver after a dive must be considered to be a DCI until proven otherwise.

If a diver shows the signs and symptoms of DCI the emergency response procedure should be initiated immediately. While transporting the diver to the nearest recompression chamber the diver should be laid down on his/her left side and the diver's body should be inclined such that the feet are placed higher than the head (to keep the bubbles in the right side and not go to the lungs or brain) and give the diver 100% oxygen (to help eliminate the nitrogen from the body tissues and blood).

3.3.4 Barotrauma

Barotrauma, which literally means “pressure injury”, is damage caused by differences in pressure between the various cavities in the diver’s body and the surrounding water. Barotrauma may occur during ascent or descent. The type of pressure injury that a diver may be exposed to depends on the body system or tissue that is affected.

Primarily the areas of the body which can be affected by barotrauma are:

- Sinuses
- Ears (Aural Barotrauma)
- Teeth
- Lungs (Pulmonary Barotrauma)
 - Interstitial Emphysema
 - Mediastinal Emphysema
 - Subcutaneous Emphysema
 - Pnuemothorax
 - Tension Pneumothorax
 - Arterial Gas Embolism

3.3.4.1 Sinuses

Sinuses are the cavities in the forehead and cheekbones, which are connected to the back of the nose. If the tubes or cavities become blocked by mucus, pressure in the cavities cannot equalise on descent/ascent. The small blood vessels will rupture during the descent/ascent and blood will often flow from the nose or into the mouth. Pain in the sinus area will also be felt due to the increase in pressure within the cavities.

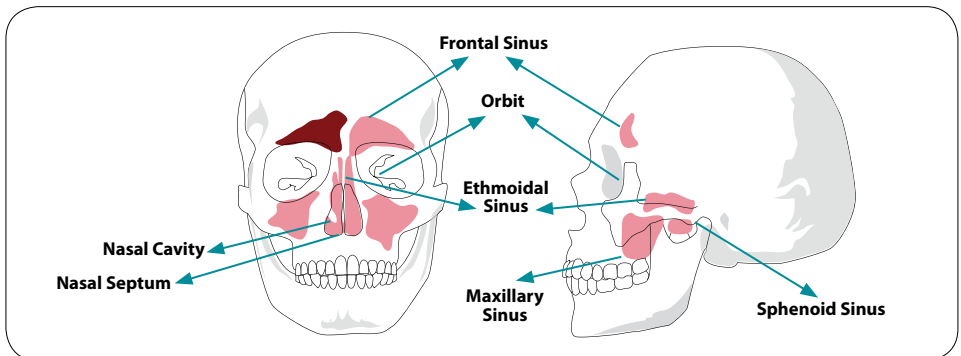


Diagram 1 : Location of Sinuses that can be affected.

To prevent such injury and damage to the sinuses **DO NOT**:

- Dive when having a cold or flu-like symptoms; or
- Take medication to relieve blocked sinuses then dive.

3.3.4.2 Ears

'EARS' - Occurs on Descent

If the Eustachian tube becomes blocked by swelling or mucus, the pressures on the inside and outside of the eardrum do not balance. When this happens the drum bulges inwards and the stretching causes pain. If descent is continued there may be bleeding in the drum as the small blood vessels are torn, and relief will be obtained only when the drum perforates. 'Ears' is usually caused by catarrh or a cold, but sometimes clearing the ears too late brings it on; in this case, ascending a few feet may clear the ears and allow the descent to be continued.

'REVERSED EARS' - Occurs on Both Descent and Ascent

- (1) On Descent. If the eustachian tube is clear and the external ear is blocked by a pad of a hood, by an earplug or by wax, the pressure change in the sealed-off external ear tends to fall behind that of the middle ear and the surrounding tissues. Because the eardrum is held from inside, it cannot move outwards to equalise the pressure, and, as the tissue fluids transmit the pressure, blood blisters tend to form in the external ear canal to equalise the pressure. These may involve the eardrum and may also burst, causing bleeding from the external ear.
- (2) On Ascent. If the eustachian tube blocks off at a depth, then as external pressure decreases on ascent, the gas in the middle ear will expand to produce a positive pressure effect within the middle ear, sometimes resulting in dizziness.

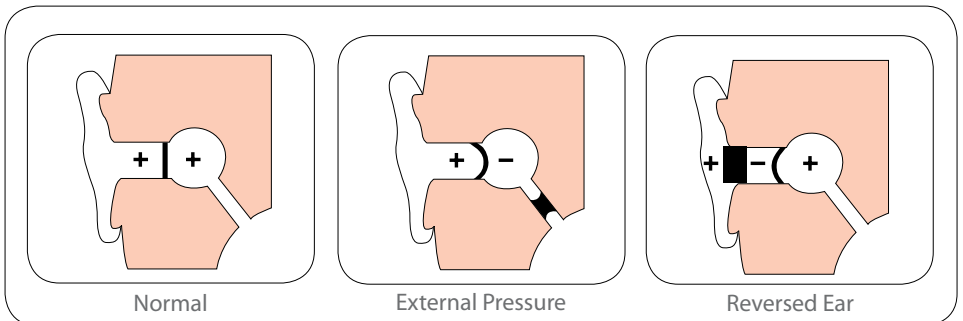


Diagram 2 : Shows a balanced eardrum, and the affect on the ear drum due to an imbalance of pressure, both externally and internally (reversed ear).

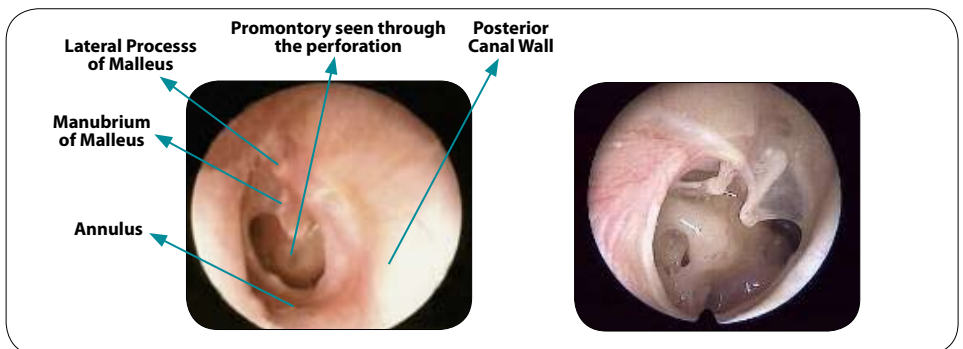


Photo 1: Shows a perforated eardrum, and the effect on the ear drum due to an imbalance of pressure, both externally and internally (reversed ear).

3.3.4.3 Middle Ear Barotrauma

The most common problem associated with diving is middle ear barotrauma, caused by inadequate pressure equalisation between the middle ear and the external environment during diver ascent.

Symptoms and Signs

Symptoms of middle ear barotrauma consist initially of the sensation of ear blockage. With further descent and greater pressure differentials, pain occurs. A conductive hearing loss (a problem conducting sound waves through the outer ear) is always present, but may not be the primary complaint because of ear pain. Mild tinnitus and vertigo may occur.

To prevent such injury and damage to the ears DO NOT:-

- Dive when having a cold or flu symptoms;
- Take medication then dive;
- Wear tight fitting hoods or block the external canal in any way;
- Allow the diver to attempt to descend if he is unable to equalise the ears.

3.3.4.4 Teeth

A cavity beneath a filling in a tooth may be susceptible to pressure differentials. The diver may suffer pain on descent and during the dive gas can become trapped in the tooth cavity while the diver is at depth. The tooth filling may be forced out by the gas over pressure during the diver's ascent. It is important that divers maintain good dental hygiene. If tooth pain is felt a dental check up should be carried out, and the diver must inform the dentist of his profession.

Care must also be given if dentures are worn, as loose dentures can be a choking hazard. If required dentures should be removed prior to carrying out the dive.

3.3.4.5 Lungs (Pulmonary Barotrauma)

Lung over-expansion injury falls under the category of decompression illness in diving medical terms and may be termed Barotrauma of the Lungs.

Lung over-expansion injury occurs when a diver holds his breath when ascending underwater. This can occur in as little as a 1.5 meter (5 foot) ascent near the surface.

When using diving equipment underwater, the diver is breathing compressed air at a pressure equal to that of the water around him/her. This means the air entering their lungs is at the same pressure as the water. If the air is held within a container or similar device that does not allow the expanding air to escape, when the diver ascends, (according to Boyles Law), the air expands due to reducing hydrostatic pressure.

The diagram below shows the relationship between depth and pressure whereby a sphere or balloon/lungs of the diver is provided air at 50metres then sealed. As the balloon rises the air will expand proportionally to the ambient pressure decreasing until the internal pressure has expanded beyond the balloon's capability and the balloon bursts.

Note

The greatest ambient pressure differential is in the 0 – 10msw (0 - 33fsw) range

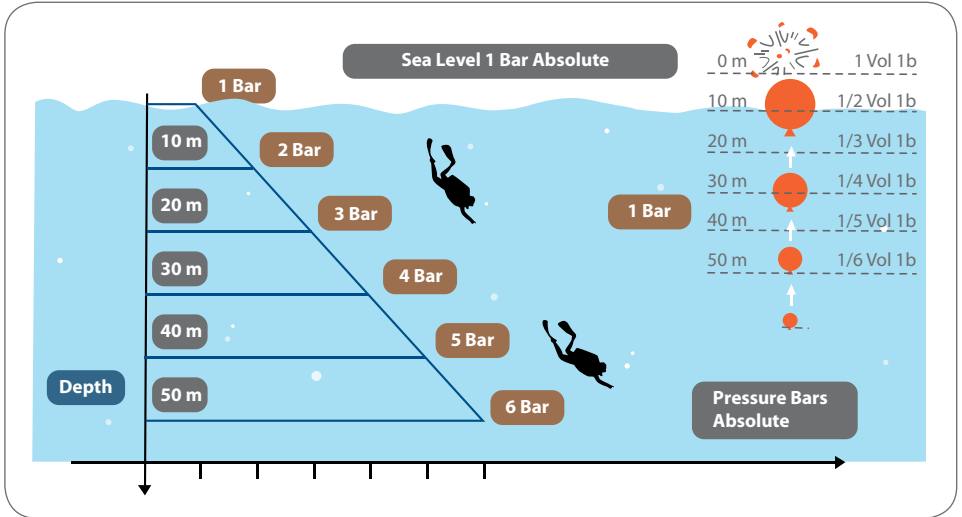


Diagram 3 : Shows the relationship between depth and pressure.

When the lung is over inflated the lung tissue tears, allowing air to enter the lung cavity and the bloodstream. The result of such a rupture causes the pulmonary capillaries and alveoli to rupture.

The rupture can cause one of six injuries

- Interstitial Emphysema
- Mediastinal Emphysema
- Subcutaneous Emphysema
- Pneumothorax
- Tension Pneumothorax
- Arterial Gas Embolism

3.3.4.5.1 Interstitial Emphysema

Interstitial Emphysema is the escape of air from the alveoli into the interstices of the lung, commonly due to trauma or violent cough (the term 'mediastinal emphysema' is more commonly used compared with the term interstitial emphysema).

Mediastinal and Subcutaneous Emphysema

If gas escapes into the interstitial (connective tissue that supports the “working parts” of an organ, in the case of the lungs the air sacs) tissue space, it may track along the outside of the airways and blood vessels into the mediastinum. This is the space between the lungs which contains the heart, great vessels and major airways. The presence of a little gas in the mediastinum is often symptomless. However, if tissues are stretched by a substantial amount of gas, mild to moderate retrosternal (behind the sternum/breast bone) pain may be felt. Other possible symptoms include a sensation of fullness in the chest or throat and a change in the tone of the voice or hoarseness. Gas in the mediastinum may migrate up into the subcutaneous tissues of the neck and, occasionally, the head. It is not usually painful and may only be detected by noticing swelling or crepitation (the skin ‘crackles’) in the neck when doing up a collar.

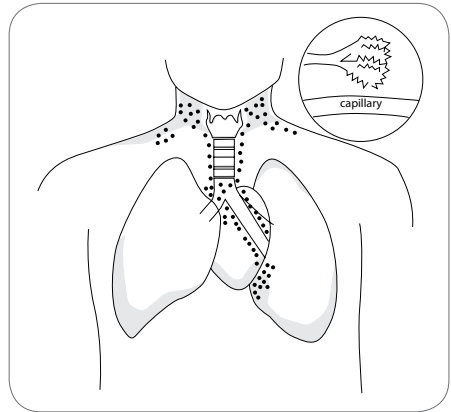


Diagram 4 : Shows the features of the Mediastinal and Subcutaneous Emphysema.

3.3.4.5.2 Decompression Pulmonary Barotrauma of Ascent

Interstitial Emphysema is the escape of air from the alveoli into the interstices of the lung,

Pulmonary Tissue Damage				
Definition	Cause	S&S	Prevention	Treatment
Damage to the alveoli of the lungs such as stretching or rupture due to the expansion of trapped gas on ascent	Breath holding, diseased alveoli and bronchioles. Blockage of the small airways at depth with mucus or catarrh. Extremely rapid ascent – blow-up	Pain behind the breastbone. Sudden cry after exhalation. Coughing bright frothy blood. Difficulty in breathing. Shock. Collapse	<ul style="list-style-type: none"> Do not hold breath on ascent. Do not dive when you have a cold. Do not ascent faster than rate of bubbles exhaled. Screen divers for lung disease – T.B., Emphysema, Asthma etc. Regular Vitalograph Tests – annually 	Keep under close observation for complications.. Seek medical advice even in mild cases.

Table 4 : Signs and symptoms of pulmonary tissue damage.

3.3.4.5.3 Pneumothorax

Interstitial Emphysema is the escape of air from the alveoli into the interstices of the lung,

Pneumothorax				
Definition	Cause	S&S	Prevention	Treatment
Air or gas in the pleural cavity	Gas escapes between the visceral and parietal layers of the pleura following rupture of the alveoli. Result – loss of negative pressure within the chest – lungs lose their ability to inflate.	Usually sudden in onset. Pain in one or both sides of the chest. Limited chest movement – difficulty in breathing. Rapid pulse – shock	As for pulmonary tissue damage.	Immediate recompression only if air embolism present. 100% oxygen to assist respirations. Prompt medical aid. Pocket of air may be aspirated with syringe by doctor. Do not decompress until doctor or DMT has examined and treated. Assess condition at each stage of decompression

Table 5 : Signs and symptoms of pneumothorax.

3.3.4.5.4 Tension Pneumothorax

This is when the gas continues to escape from the perforated lung, and the pressure buildup within the chest may eventually cause both lungs to collapse. Cyanosis (a blue coloration of the skin, lips and fingernails) will become pronounced and shock, unconsciousness and death may ensue unless the patient is treated appropriately.

Tension pneumothorax is a rare condition under normal conditions at the surface. However, a simple pneumothorax which occurs at depth may increase in size during decompression and may effectively become a tension pneumothorax and cause lung collapse. If a diver's condition deteriorates during ascent, especially if the symptoms are respiratory, a pneumothorax should always be suspected.

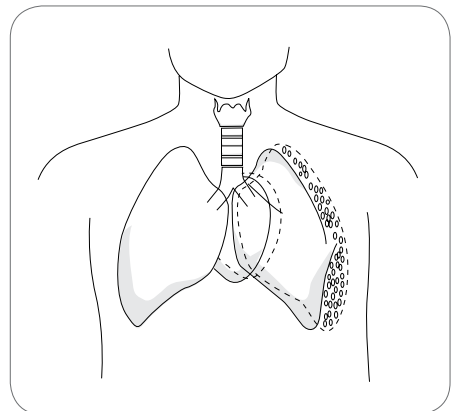
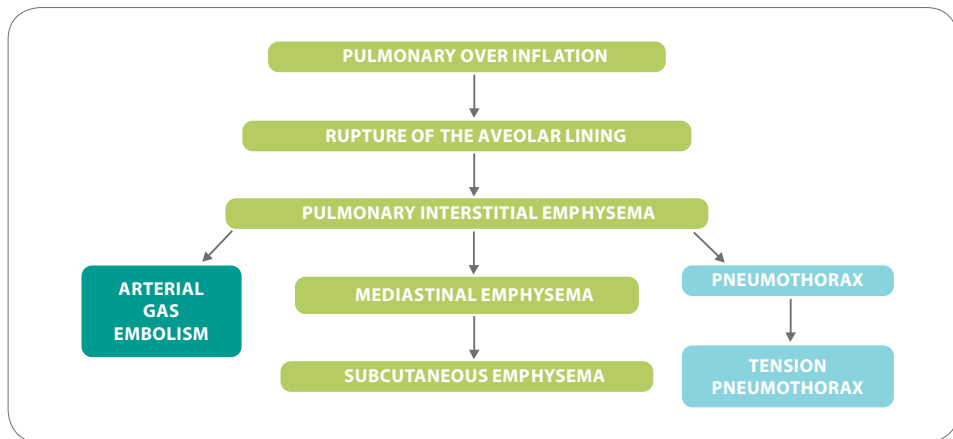


Diagram 5 : Shows the features of a Tension Pneumothorax.

The sequence of a Pulmonary Over Inflation is outlined below – providing guidance on possible occurrences.



The most common causes of lung over-expansion injury are panic and ignorance. Other less common causes are choking, nausea, carelessness, and even smoking. Smoking can destroy the surfactant which keeps the lungs from sticking shut when they are vented. This can cause parts of the lungs to stick shut and simulate holding ones breath.

3.3.4.5.5 Arterial Gas Embolism

Arterial Gas Embolism (AGE) results from bubbles entering the lung circulation, travelling through the arteries and causing tissue damage at a distance by blocking blood flow at the small blood vessel level.

Arterial Gas Embolism				
Definition	Cause	S&S	Prevention	Treatment
Gas blockage in the arterial circulation following escape of gas from the alveoli into the pulmonary capillaries and veins.	Over distension and rupture of alveoli due to trapped gas.	Usually occurs within five minutes of surfacing. Confusion, convulsions, lowered consciousness, coma. Visual disturbances, dizziness, disorientation. Paralysis – Hemiparesis. Blood stained froth around mouth.	As for pulmonary tissue damage	Immediate recompression to 18 msw (60 fsw) E.A.R and E.C.M as required. 100% oxygen during transportation to chamber. Keep on left side with feet elevated during transport. Medical aid as soon as possible.

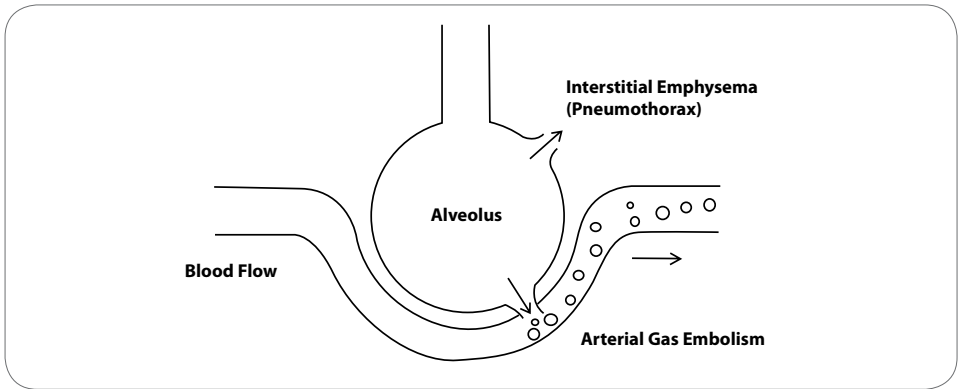


Diagram 6 : An example of Alveoli rupture and route of the escaping gas/air.

3.3.5 Shallow Water Blackouts

A shallow water blackout is a loss of consciousness caused by cerebral hypoxia (lack of oxygen supply to the brain) towards the end of a breath-hold dive in water typically shallower than 5 metres (16 feet), when the swimmer does not necessarily experience an urgent need to breathe and has no other obvious medical condition that might have caused it. Breath-hold diving and hyperventilation **MUST NOT** be practiced during occupational diving operations.

3.3.6 Nitrogen Narcosis

Nitrogen is an inert gas that is a main component of the atmosphere. To be precise, 79% of air is composed of nitrogen. It is inert, meaning that it does not take part in energy transformations. In diving, inert gas narcosis impairs the diver's ability to think clearly. The most common form, nitrogen narcosis, is caused by breathing compressed air at depth.

The signs of narcosis are:

- Loss of judgment or skill;
- A false feeling of well-being;
- Lack of concern for job or safety;
- Apparent stupidity;
- Inappropriate laughter; and
- Tingling and vague numbness of the lips, gums and legs.

Disregard for personal safety is the greatest hazard of nitrogen narcosis. Divers may display abnormal behaviour such as removing the regulator mouthpiece or swimming to unsafe depths without regard to decompression sickness or air supply whereby such actions can be fatal.

Inert gases vary in their narcotic potency. The effects from nitrogen may first become noticeable at depths exceeding 90fsw (30msw) but it has been known to affect divers at shallower depths of less than 25msw and becomes more pronounced as the depth increases. There is a wide range of individual susceptibility and some divers, particularly those experienced in deep operations with air, can often work during deep dives without serious difficulty.

Depth (fsw)	Symptoms Include
<90fsw/30msw	Intoxicating effect similar to that of alcohol Slowing of mental activity
>90fsw/30msw	Slowing of reaction time and reflexes General euphoria fixation of ideas

Table 6 : Summary of nitrogen narcosis effects.

The following signs and symptoms may also be displayed by the diver:

- Difficulty in concentrating or reasoning;
- Difficulty in remembering what to do or what has already been done;
- Observations often inaccurate;
- Likely to make incorrect decision about what to do; and
- Diver may not care about job or safety.

There is no specific treatment for nitrogen narcosis; the diver must be brought to shallower depths or the surface where the effects are not felt. Any decompression stops required should be completed in accordance with the diving tables being used.

It is the responsibility of the diving supervisor to monitor the diver and if necessary, abort the dive if the diver exhibits signs of Nitrogen Narcosis at any time.

3.3.7 Oxygen Toxicity

Oxygen toxicity is a condition resulting from the harmful effects of breathing oxygen (O₂) at elevated partial pressures.

The upper limit for breathing 100% in the water is 6-8msw, which is equivalent to a PPO₂ of 1.6 to 1.8 bar.

Absolute pressures of this order and above can produce convulsions. The convulsions are like 'grand mal epilepsy' i.e. tonic, clonic (rhythmic jerking movements of the arms and legs) and coma.

When oxygen is breathed at a partial pressure exceeding 1.6 bar, it produces toxicity more rapidly and affects the brain.

The following Table 7 indicates the possible effects of different oxygen partial pressures.

Note

Susceptibility to oxygen toxicity varies tremendously between individuals

		Central Nervous System (ACUTE)	
2.8 BAR		Hyperoxia	Pulmonary Hyperoxia (Chronic)
1.6 BAR		Hyperoxia	
0.5 BAR			
0.2 BAR		Normal	
0.16 BAR			
		Hypoxia	
0.0 BAR		Anoxia	

Table 7 : The effects of partial pressure of oxygen (PPO₂) on the body.

There are two principal types of oxygen toxicity that may affect the diver:

- Acute Oxygen Toxicity/Central Nervous System (CNS) Toxicity: characterised by convulsions followed by unconsciousness, occurring under hyperbaric (decompression chamber) conditions, high partial pressure of oxygen for a short period.

CNS Toxicity is caused by short exposure to high concentrations of oxygen at greater than atmospheric pressure.

- Chronic Oxygen Toxicity: Pulmonary (lungs), characterised by difficulty in breathing and pain within the chest (may occur while using oxygen during decompression treatment in a chamber).

Pulmonary toxicity is caused by breathing oxygen at elevated pressures for extended periods.

The result of breathing oxygen at elevated concentrations is termed hyperoxia, an excess of oxygen in body tissues.

Prevention of oxygen toxicity is an important precaution whenever oxygen is breathed at greater than normal partial pressures, and has led to the use of protocols for the avoidance of oxygen toxicity in such fields as diving and hyperbaric oxygen therapy.

Oxygen may be utilised during occupational diving operations (dives) if a planned decompression diving operation is carried out using an industry decompression table that requires in-water decompression using oxygen. Oxygen can also be utilised during therapeutic treatment of diving-related injuries under controlled hyperbaric conditions.

A suitable quantity of oxygen and suitable oxygen 'Provider Set' **MUST** be available on every dive site for use in an emergency.

3.3.8 Carbon Dioxide Buildup

Carbon Dioxide Toxicity (Hypercapnia) is an abnormally high level of carbon dioxide in the body tissues.

In diving operations, hypercapnia is generally the result of a buildup of carbon dioxide in the breathing supply, respiratory system or body tissues caused by:

- Inadequate ventilation of surface-supplied helmets;
- Inefficient diving equipment- faulty helmet/ mask/oral nasal unit;
- Excess carbon dioxide in the helmet supply;
- Inadequate lung ventilation in relation to exercise level (caused by controlled breathing, excessive apparatus breathing resistance, increased oxygen partial pressure, or increased gas density);
- Over exertion during work and irregular breathing patterns (working hard); and
- Any cause of increased dead space, such as shallow and rapid breathing.

Carbon dioxide levels in the blood can increase, causing shortness of breath and sedation, resulting in carbon dioxide toxicity.

Signs and Symptoms

When there is rapid onset – unconsciousness is the first feature. When there is slow onset – throbbing headache over eyebrows, increased respirations and rapid pulse, facial flushing and sweating, light headaches preceding unconsciousness, nausea, respiratory and cardiac failure and eventually death may result.

Prevention

Ensure breathing of pendulum type to maximise amount of air being inhaled and exhaled. Design breathing apparatus with minimum dead space. Ensure sufficient volumetric supply to the regulator/helmets.

Treatment

If carbon dioxide buildup is experienced underwater the following actions should be taken:

- Slow down/stop work;
- Regain breathing pattern and flush helmet/mask with freeflow air supply valve;
- Recover diver, rest and give fresh air or 100% oxygen; and
- Monitor diver for other signs and symptoms.

3.3.9 Carbon Monoxide Buildup

Carbon monoxide poisoning occurs after the inhalation of carbon monoxide gas. Carbon monoxide (CO) is a product of combustion of organic matter under conditions of restricted oxygen supply.

Carbon monoxide is colorless, odourless, tasteless, and non-irritating, making it difficult for people to detect.

Carbon monoxide is a significantly toxic gas, and CO poisoning is the most common type of fatal gas poisoning in many countries.

Symptoms of mild poisoning include headaches, vertigo, nausea, and flu-like effects. Larger exposures can lead to significant toxicity of the central nervous system, heart and even death.

Sources

The most common source of CO that leads to poisoning are the exhaust gases from internal combustion engines.

CO poisoning can occur in diving due to a badly sited compressor intake, where carbon monoxide is drawn into the air compressor which compresses impure air into the diver's air cylinder.

Generators and propulsion engines on boats have also resulted in fatal carbon monoxide exposures. CO breathed in prior to a dive, remains within the body systems and becomes toxic when the body is exposed to increased ambient pressure during a dive.

Treatment

Carbon monoxide poisoning is difficult to treat because of its affinity with hemoglobin, as it displaces oxygen in the hemoglobin.

Treatment largely consists of administering 100% oxygen and/or hyperbaric oxygen therapy.

3.4 Flying After Diving

Although it is unlikely that diving operations carried out within the territory of Singapore will involve flying after diving, in the event such travel is required on completion of any diving project the following guidelines should be followed.

Reference for flying after diving is made to the Diving Medical Advisory Committee information note DMAC 007. Table's 8 and 9 provide guidance on flying after air diving.

Two levels of cabin altitude are considered, viz.:

- A maximum altitude of 2000' (600m), provided the predicted flight plan has been checked.
- A maximum altitude of 8000' (2,600m), all other flights.

Diving without Decompression Illness (DCI) Problems

	Time Before Flying At Cabins Altitude	
	2000' (600m)	All other flights
1. Non-stop dives Total time under pressure less than 60 minutes within previous 12 hours.	2 hours	8 hours (24 hours)*
2. All other air diving (less than 4 hours under pressure)	12 hours	24 hours

*The 8 hours applies to short flights. For longer flights, as for example intercontinental flight the time is extended to 24 hours. It is recommended to wait 24 hours before flying, following any diving activity.

Diving after Decompression Illness (DCI) Treatment/Therapy

The times below are the minimum times for flying after completing decompression therapy.

	Minimum time from Completion of therapy	
	2000' (600m)	All other flight
1. Immediate and complete resolution of symptoms on first recompression.	24 hours	48 hours
2. Cases without immediate response or with residual symptoms must be decided on an individual basis by a diving medical specialist. Generally wait as long as possible.	Consult a diving medical specialist. Consideration should be given for 100% oxygen during flight.	

Table 8 : Flying after diving.

Following therapy for DCI, advice should be sought from a diving medical specialist

Note

'Non Stop Dives' are dives that do not incur any decompression requirements

Decompression Illness in Flight

In addition, the following procedures are recommended for decompression illness occurring during a scheduled flight:

- Where the diver's symptoms consist only of pain in a limb, he should be treated with analgesics (painkillers) and oxygen if available, and the plane can continue to its destination without diversion or adjustment in altitude.
- When the diver has any other symptoms, immediate advice should be sought from a diving medical specialist. It may be necessary to reduce the cabin altitude or divert to the nearest airport. In the meantime, the patient should be given oxygen if available.
- Following decompression involving dysbaric illness is a term that covers a broad range of complex conditions associated with decompression illness, flying is not permitted for 48 hrs.

4. Personnel and Responsibilities

This section discusses personnel and responsibilities that **MUST** be considered when planning any diving operation.

4.1 Site owners

Site owners have a responsibility to inform the diving contractor of any underwater or above water items of plant, pipelines, equipments or subsea structures under their control that may cause a hazard to the diver and dive team during the diving project.

This will include but not be limited to: physical hazards such as locks, weirs, water intakes, propellers, discharge points, debris or scaffolding, as well as any chemical hazards that may be present at the work site.

Such information **SHALL** be provided in writing to the diving contractor.

4.2 Client/Main Contractor/Others

The client is the organisation/company who has placed a contract with a diving contractor for a project. The client will usually be the operator or owner (site owner) of a vessel, dock, proposed or existing installation, pipeline or other structure where the diving project is going to take place, or may be a contractor acting on behalf of the operator or owner. If the operator or owner appoints an on-site representative then such a person **SHALL** have the necessary experience and knowledge to be competent for this task.

The main contractor is the company carrying out work for the client and overseeing the work of the diving contractor according to the contract. If the main contractor appoints an on-site representative then such a person **SHALL** have the necessary experience and knowledge to be competent for this task. In some cases the main contractor will be the diving company.

The client/main contractor actions and activities can affect the safety of the dive team, even though they are not members of the dive team.

Clients/main contractor are required to have a formal risk management and safety management system in place to cover diving activities, an example of which will be a permit-to-work system (reference: Annex L).

Items of machinery that could endanger a diver must be immobilised by a Lock Out/Tag Out system, an example of which is shown in the photograph below (reference: Annex B).

These organisations or personnel will need to consider carefully the actions required of them. Their duties should include:

- Agreeing to provide facilities and extend all reasonable support to the diving contractor and diving supervisor in the event of an emergency. Details of the matters agreed should form part of the planning for the project;
- Considering whether any underwater or above-water items of plant or equipment under their control may cause a hazard to the diving team. Such items include:
 - Vessel/floating structure propellers and anchor wires;
 - Underwater obstructions;
 - Pipeline systems under pressure test or with a pressure lower than the pressure at the diver's work location;
 - Subsea facilities;
 - Water intakes or discharge points causing suction or turbulence;
 - Equipment liable to start operating automatically;
 - Appropriate isolations and barriers (mechanical, electrical, optical, hydraulic, instrumentation isolations and barriers); and
 - Other vessels/activities in the area of the diving project.
- Inform the diving supervisor of any changes or activities that may affect the safety of the diving operation;
The diving contractor will need to be informed of the location and exact operational details of such items in writing and in sufficient time to account for them in the risk assessments;
- Ensuring that sufficient time and facilities are made available to the diving contractor at the commencement of the project in order to carry out all necessary site-specific safety and familiarisation training;



Photo 2 : Lock Out/Tag Out notice on ship equipment panel.

- Ensuring that other activities in the vicinity do not affect the safety of the diving operation. They may, for example, need to arrange for the suspension of supply boat unloading, overhead scaffolding work, use of cranes, bunkering etc; and
- Ensuring that a formal control system, for example, a permit-to-work system, exists between the diving team, the installation manager and/or the master.

Other support personnel may include (but not be limited to):

- Master of the vessel/Boat coxswain;
- Client representative;
- Vessel crew; and
- Project personnel (engineer, surveyor, etc.).

A risk assessment must be carried out to determine the requirement for support personnel. All support personnel must be qualified to act in their designated capacity. Along with the diving personnel, they must be suitably equipped to carry out their duties safely.

4.3 Diving Company/Contractor

The diving contractor is the employer of the divers, and has direct responsibility to ensure that a safe system of work is in place, this includes:

- The safety and health of all persons employed;
- That the diving project is properly and safely managed;
- Ensuring the diving project plan is available;
- A management of change procedure is established;
- Risk assessments have been carried out;
- The location from which the diving operation is to be carried out is suitable and safe;
- Emergency and contingency plans have been prepared;
- The dive team has been adequately briefed on all aspects of the diving operation;
- There are sufficient personnel in the dive team to carry out the dive project safely;
- The dive team personnel are qualified and competent;
- Dive supervisors are appointed in writing;
- Adequate arrangements are in place for first aid and medical treatment (Reference para 4.8);
- Suitable diving plant and equipment is provided;
- The diving plant and equipment is certified and maintained;
- The divers are medically fit to dive;
- Dive records are maintained and kept; and
- Suitable onsite familiarisation briefing is provided to all members of the dive team.

The Diving Contractor must have:

- Valid and adequate insurance cover. A copy of the insurance policy **MUST** be available at each work site (divers working as freelance divers **SHALL** be covered under this policy);
- Current versions of the relevant documents and data are available at all locations where operations essential to the effective functioning of the OSH system are performed;
- A Dive Plan (DP) or Diving Project Plan (DPP) **MUST** be available at the work site;
- A diving operations manual, (Reference Annex G for sample format) a copy **MUST** be available at the work site; and
- A copy of this TA should be available at the work site.

Note

All the above documentation **SHALL** also be available at the diving contractors onshore office facility.

4.4 Diving Supervisor

The diving supervisor is the appointed in writing by the diving contractor and is responsible for, and in immediate charge of the diving operation. Only the diving supervisor can commence diving operations (ie, put the diver in the water) subject to the appropriate work permits etc. Other related parties, such as the client, the master of the vessel etc. can tell the diving supervisor to terminate diving operations for safety or operational reasons.

The diving supervisor **SHALL**:

- Be appointed in writing by the company/person employing the supervisor;
- Be trained and has passed relevant courses at an accredited organisation to supervise occupational diving operations;
- Be present at all times while a diver is in the water;
- Be present while a diver is in a compression chamber;
- Not dive while acting as a diving supervisor, unless the supervisor has documented the handover of the diving operation to another diving supervisor who is appointed in writing by the diving contractor;
- Be trained in the recognition and management of diving emergencies;
- Be trained in first aid;
- Be capable of recognising the symptoms of DCI;
- Be capable of supervising therapeutic treatment under the direct or in direct consultation with a hyperbaric physician. Where the decompression chamber is off-site, is familiar with the procedure for transporting the diver(s) to the compression chamber;
- Ensure that the plant and equipment comply with legislative requirements, and record all checks on the dive record or equipment check list;
- Ensure that there is sufficient and appropriate breathing mixture available for the diving operation and any possible emergency;

- Ensure that each diver is in possession of a valid and approved medical certificate (Reference para 4.8 for medical examination requirements)
- Ensure that all possible foreseeable hazards have been evaluated and are fully understood by all relevant parties and that, if required, training is given;
- Ensure a risk assessment has been carried out for the diving operation that is planned to be carried out;
- Prior to commencement of the dive operation carryout an on-site job safety analysis (JSA);
- If the situation has changed, carryout further risk assessment and management of change process;
- Ensure that the operation they are being asked to supervise complies with the requirements of the WSH Act, local code of practice and this TA;
- Ensure that each diving team member is briefed on their duties;
- Have clear communications with any other personnel involved with the diving operation such as – vessel master; deck crew; crane operator; port authority etc. (Note: Clear communications is outlined in para 5.2.3.3);
- Must maintain communications with the diver at all times, record all communications with the diver and maintain the recording for at least 24 hours;
- Maintain the Diving Operations Log Book; and
- Maintain personal record of diving operations supervised.

4.5 Diver

Divers are responsible for undertaking duties as required by the diving supervisor:

A diver **MUST**:

- Be trained and must have passed relevant courses by an accredited organisation, and have experience commensurate with the required diving mode (i.e he knows what to do and how to do it);
- Be trained in First Aid (Reference para 4.8);
- Be at least 18 years of age;
- Be in possession of a valid dive medical certificate (Reference para 4.8 for medical examination requirements);
- Inform the diving supervisor if there is any medical or other reason why they cannot dive;
- Ensure that their personal diving equipment is working correctly and is suitable for the planned dive;
- Ensure that they fully understand the dive plan/dive project plan and are competent to carry out the planned task;
- Know the routine and emergency procedures;
- Report any medical problems or symptoms that they experience during or after the dive;
- Report any equipment faults, other potential hazards, near misses or accidents;
- Check and put away personal diving equipment after use; and
- Keep their logbooks up-to-date and presenting it for signing by the diving supervisor after each dive.

4.6 Divers Attendant

The diver's attendant **SHALL** assist the diver in preparation and during the diving operation. The diver's attendant **MUST**:

- Be briefed by the diving supervisor on the diving task to be carried out by the diver;
- Fully understand the actions required in the event of an emergency;
- Be trained in First Aid (Reference para 4.8);
- Understand the requirements of underwater work;
- Understand diving signals and communications; verbal and line signals;
- Understand decompression procedures; and
- Have a working knowledge of diving plant and equipment.

In normal circumstances the diver's attendant will be a qualified or trainee diver, in the event the divers attendant has no formal training in the duties and responsibilities required, such training **MUST** be provided.

4.7 Standby Diver

There **SHALL** be a standby diver present on the surface whenever a diver is underwater. There **SHALL** be a minimum of **one (1)** stand by diver for every **two (2)** divers in the water. The stand by diver **MUST** be fully dressed (his helmet/mask shall be ready to put on when instructed to do so by the diving supervisor) with all his diving equipment checked and tested, he will be in a position where he can access the water quickly, and will be ready to dive if required by the diving supervisor.

The standby diver **SHALL**:

- Be trained and must have passed relevant courses by an accredited organisation, and have experience commensurate with the required diving mode (i.e he knows what to do and how to do it);
- Be dressed and equipped (he should be fully dressed in ready to dive with all communications and air supply checks completed; and then sat comfortably only requiring to put the diving mask/helmet on before entering the water) to enable immediate entry into the water to provide aid or assistance to the working diver; and
- The standby diver's umbilical **MUST** be at least 5m (15ft) longer than the divers umbilical.

Note

Where two divers are in the water at the same time, they **SHALL** not act as standby diver for each other under any circumstances. A standby diver **MUST** be present on the surface.

4.8 Health, Fitness and First Aid

The medical examination on a commercial diver should be rigorous and a high standard of medical fitness is required. The medical examination shall be conducted by a doctor who is suitably qualified and familiar with the medical problems of diving. He should preferably be registered as a Medical Physician and have undergone a Diving and Hyperbaric Medical Physician Course.

A Member of the dive team who is to dive **MUST** be in possession of a valid dive medical Certificate issued by the doctor mentioned above.

The dive medical certificate **MUST** have been issued less than 12 months previously and include the requirements specifically for a diving medical. (Reference Annex O- Sample Divers Medical Form)

Non-diving team members' medical certificates must commensurate with their age and duties, and hold a valid medical that has been issued less than 24 months previously.

All of the diving team members should be qualified in First Aid, and should include the following training:

- First Aid Certification;
- Administration of oxygen (oxygen provider);
- Cardiopulmonary Resuscitation (CPR);
- Automated External Defibrillator (AED); and
- Diving related injury or illness; cause's, signs, symptoms and treatments.

The above training and certification is valid for a 3 year period and refresher training will be required to maintain a current, certified First Aid qualification.

Divers should not dive unless they are in good health, i.e no diving if one is suffering from a cold or flu, effects of alcohol, or any respiratory illness, no matter how mild. For any diver on medications for acute or chronic diseases or illnesses, the diver should be reviewed by a Diving Medical consultant/physician for fitness to dive.

A First Aid Box (in accordance with WSH (First Aid) Regulations) **SHALL** be available on site to treat minor first aid cases and should also include medication for marine animal stings. In addition to the First Aid Box, there **SHALL** be an Oxygen Provider set with sufficient high pressure oxygen quantity to provide oxygen to an injured diver for the duration (time) required to get to the nominated emergency decompression chamber.

4.9 Training

All diving team members (Dive Supervisor, Divers, and Attendants) **MUST** have attended and passed the relevant training course provided by an accredited organisation for the work that it is planned for them to carry out.

There are different standards of diver training qualifications available, including military diver training, recreational diver qualification (e.g. PADI, SSI, NAUI and Technical diver) and industry recognised commercial diver training certification.

Recreational diving qualifications and military diver training **SHALL** not be suitable for occupational diving operations outlined in the scope of this TA.

5. Equipment

The mode and method of diving equipment used **MUST** be in accordance with the requirements of this TA.

5.1 Equipment Standards

The diving contractor will need to be satisfied that the equipment provided for the diving project is suitable for the use to which it will be put, in all foreseeable circumstances, on that project. Equipment suitability can be assessed by the evaluation of a competent person, classification society, clear instructions or statements from the manufacturer or supplier and testing. In this respect it **MUST** be ensured that in date test certificates for all equipment are available where required.

5.2 Minimum Equipment Required to Carryout a Diving Operation

The following list outlines the minimum diving equipment required to carry out one (1) diving operation with one (1) diver in the water.

- Sufficient air supply for the diver (air **MUST** be breathing grade, in accordance with BS EN 12021:1999) provided from a suitable source; vessel air and industry air compressors are not acceptable.
- Independent sufficient air supply for the standby diver.
- Emergency air supply for the diver and standby diver.
- Suitable breathing apparatus for the diver.
- Suitable breathing apparatus for the standby diver.
- Emergency bailout cylinder for the diver and standby diver.
- Safe means to enter the water.
- Safe and suitable means to exit from the water and recover an unconscious diver.
- First aid and medical equipment.
- Personal diving equipment (Reference paragraph 5.2.7).
- A decompression chamber (Reference paragraph 5.2.10).

The following information provides data on the types of equipment that can be used to meet the minimum equipment requirements.

5.2.1 Self Contained Breathing Apparatus (SCUBA)

Self Contained Breathing Apparatus (SCUBA) has limitations that must be considered for its use on occupational diving operations. These limiting considerations are:

- The time a diver can spend under water is limited by the amount of gas that the diver can carry with him. This is a particularly a problem if the diver is working hard and breathing heavily.
- In many commercial diving locations there are obstructions under water. If a diver becomes entangled or fouled then the limited amount of breathing gas available using SCUBA can present a serious safety problem. The SCUBA diver, in such situations is also likely to become distressed, leading to an increased breathing rate and faster consumption of the limited breathing gas supply.
- Although some SCUBA systems do have a reserve facility these have a record of failure in an emergency. They can also be easily activated and depleted without the diver's knowledge. The reserve supply of air carried by a SCUBA diver is normally extremely limited.
- The SCUBA divers can use what is known as 'personal through-water communications' (battery powered systems usually used by recreational divers), that do not use a hard wire system to the surface. Such non hard-wired systems may not be reliable and often do not provide clear and recordable communications. In general such systems are operated by direct diver action thus requiring the diver to be conscious. Such systems do not enable the diving supervisor to monitor the diver's breathing patterns.
- A SCUBA diver normally has to carry his own depth gauge and watch. This is an extra task for him to think about while diving as he has to control his own decompression. Some SCUBA divers wear decompression 'computers' but these are programmed for recreational users and may not be reliable for the heavier types of work normally carried out by occupational divers.
- It is sometimes said that SCUBA divers are much more mobile under water than divers using surface supplied equipment. While this may be true of a free-swimming SCUBA diver, with no lifeline or other attachment to the surface, the risks of free swimming (such as the diver going missing) are not acceptable in occupational diving outlined in this TA. An example, a free-swimming SCUBA diver could be seriously affected by currents. If the SCUBA diver is connected to the surface by a lifeline then he is no more mobile than a diver wearing normal occupational surface supplied diving equipment. With suitable training and competence a diver can work more efficiently and safer using a lifeline and/or surface supplied diving equipment.
- Emergency air supply for the diver and standby diver.

When SCUBA diving equipment is used the following items **MUST** be included with the equipment:

- Diver's locating device securely attached to the diver's body
- A full face mask c/w oral nasal and communications
- A lifeline attached to the diver's harness
- Hard wire communications so the diving supervisor can communicate clearly with the diver and record all communications (breathing pattern)
- A 'pony bottle' c/w second stage regulator for use as an emergency air supply

5.2.2 Diving Masks and Helmets (Half and Full Face)

The diving masks keep the diver alive by supplying him with breathing gas (except for the half face mask).

A half face mask (used with a separate mouthpiece) cannot be considered to be a safe method for occupational diving. In inland/inshore diving, with its inherent environmental hazards, a mouthpiece is very vulnerable to accidental dislodgement. In harbour diving, where the risk of contamination is always present, a mouthpiece offers no protection against chemicals or foreign bodies which may be present in the water.

A full face mask/helmet **SHALL** be used for all occupational diving operations, including those using SCUBA. There is a wide range of full face masks available which can be used with SCUBA, all of which offer superior performance and safety than that of a half face mask. There are also many types of communications systems available that can be fitted to full face masks.

A full face mask, fitted with a communications system, allows the diving supervisor to maintain contact with the diver, and assists in maintaining the diver's safety and well-being during the course of the dive as well as allows the work task to be managed efficiently.

The use of the diver's helmet provides 'head protection' for the diver while at work.



Half face mask



Full face mask; no side block assembly



KM 18 Band mask



KM 17-'Helmet'

Photo 3 : Examples of dive helmet/masks.

Note

The full face mask, used with SCUBA diving equipment with no side block assembly, does not allow for an emergency air supply other than from the SCUBA cylinder. The bandmask and helmet has a side block assembly that allows the connection of the main air supply umbilical and bailout cylinder providing an independent emergency air supply.

Emergency bailout connection

Normal air supply connection



KM 27 Helmet coupled with side block assembly



KMB 18 Band mask coupled with side block assembly

Photo 4 : Examples of Side Block Assembly.

5.2.3 Surface Supplied Diving Equipment (SSDE)

The basic surface supplied diving equipment comprises of the following items:

- Sufficient air supply for the diver (air **MUST** be provided from a suitable source; vessel air and industrial air compressors are not acceptable);
- Independent sufficient air supply for the standby diver;
- Emergency air supply for the diver and standby diver;
- Dive control panel;
- Diver's mask/helmet;
- Diver's umbilical securing carabineers;
- Diver's communications box;
- Diver's harness; and
- Diver's locating device securely attached to the diver's body.

Each of the listed items is describe below.

5.2.3.1 Air Supply

At any time the diver is in the water he/she **SHALL** have a primary air supply and secondary emergency air supply. The stand by diver **SHALL** also require an independent primary air supply and a secondary emergency air supply.

The air supply panel supplies breathing air to the working and standby diver - except for the SCUBA diver who carries his air supply in high pressure (HP) cylinders on his back. The air supply panel receives low pressure (LP) or HP air from storage cylinders. This HP air supply can be divided into primary and secondary supply, which gives the diver a second air supply if required. The air supply is regulated



Photo 5 : Typical portable air supply panel.

(de-pressurised) to an appropriate delivery pressure and is then directed to the diver via a dedicated air supply hose.

Some air supply panels (example shown in the photograph) also incorporate a communication radio and depth gauges that allow the dive supervisor to check the depth of the diver. (Diver depth and time in water are the critical dive components that determine if the diver requires decompression).



Photo 6 : Typical diver's umbilical.

5.2.3.2 Diver's Umbilical

The photograph (photo 6) shows a typical air diver's umbilical. This particular umbilical is probably in excess of 330ft (100meters) long, however umbilical's can be whatever length is deemed suitable by the diving contractor (Note: the diver's air hose **MUST** be a single length. No joins are permitted). The standby diver's umbilical **SHALL** be at least 5 metres longer than the diver's umbilical to allow the standby diver to reach the diver in the event of an emergency.

A typical umbilical is comprised of the following components:

- ¼" (6mm) diver's depth gauge hose;
- 3/8" (8mm) air supply hose;
- Strength member (polypropylene rope);
- Combined communications/video cable (optional for project specific requirements but recommended for normal use); and
- Hot water hose supply (optional for certain environmental conditions).

While the umbilical looks heavy, it is surprisingly light underwater, and complies with the requirements for safe surface diving practice. The umbilical can be manufactured as positive or negatively buoyant. The umbilical is also marked for length in 5m increments. The umbilical marking gives an indication of the distance of the diver from the tending point. It is bad practice to allow an excessive length of umbilical to be deployed. Excessive umbilical in the water would increase the probability of diver fouling or entanglement.

The tender should always be able to feel the diver through his umbilical.

5.2.3.3 Divers' Communications Equipment

Divers' communications equipment range from sophisticated wired units that allow clear speech to the diver to recreational personal communications units which operate on wireless 'through water technology' that give a slightly distorted, but understandable speech.

All occupational divers' equipment **MUST** include hard wire communications. The use of 'line pulls' as emergency signal requirements should also be known and understood by the diving personnel.



Photo 7 : Typical divers communications equipment.

5.2.3.4 Recording Equipment

Where a diver's communications unit is in use, there **SHALL** be a method of recording the diver's/dive supervisor's conversations and the diver's breathing pattern. The recording equipment can range from a simple cassette type system to a DVD hard drive unit that can record communications and video from a diver's hat camera.

Such systems are invaluable for recording information that may be a requirement of the diving project.

Diver recordings are also very useful in the event of a diving incident, where they can assist in determining actions and activities prior to and during a diving incident (similar to aircraft 'black boxes').



Photo 8 : Recording equipment (set up beside air dive panel).

5.2.4 Bail Out Bottle (Cylinder)

All divers **MUST** carry an emergency air supply, commonly known as a bail-out-bottle. If the SCUBA diver is wearing a twin-set then it is normal to breath one cylinder down and equalise from the second cylinder when required. This equalisation process is done twice before the diver is required to return to the surface. Or an alternative 'pony bottle' maybe attached to the SCUBA cylinder for use with a dedicated second stage regulator.

In all situations the emergency air supply carried by the diver must be sufficient to allow him to return to a safe location/the surface.

It shall be the diving supervisor's responsibility to calculate the bailout bottle/cylinder endurance for the diving operation and ensure there is a minimum of 1 minute of breathing for every 10 metres of umbilical paid out from the tending point. (Reference Para 5.2.13 for breathing rate and consumption calculations).

Each bailout cylinder shall be colour coded correctly and named on the cylinder as 'diving air' so that it can be clearly identified for use. At no time should any other gas mix be used in bailouts that are identified for diving air.

The cylinder serial number and hydro test date must be clearly visible.

The bailout cylinder (bottle) shall be securely fitted to a back pack/harness for use by the diver.



Photo 9 : Examples of bail out bottles (diver emergency air supply).



Photo 10 : Cylinder test dates and harness.

Each of the bailout bottles/SCUBA cylinders are fitted with pillar valves for the connection of the first stage regulators. There are varied designs of pillar valves:

- **J-Valve** - The "J" valve has a lever that when raised cuts off airflow at about 300 psi - by lowering the lever you gain access to the last 300 psi. This valve was used before the advent of the SPG (Submersible Pressure Gauge) as an emergency indicator of the time to end the dive.
- **"K" valve** is the standard on/off valve commonly seen on most tanks.
- The **"H" valve** has two independently controlled orifices and will accept two first stage regulators. Many will accept both DIN and Yoke regulators (via a yoke insert).
- The **"Y" valve** is like the "H" valve but older, and is less commonly used today as the "H" valve can be adapted to a manifold for doubling tanks whereas the "Y" valve can't be used in such a manner.



Photo 11 : J valve.



Photo 12 : "K" valves.

5.2.5 Dive Computers

The use of dive computers for managing occupational diving operations is not recommended, and the use of dive computers **SHALL** not be the primary means of managing the dive.

It is the responsibility of the diving supervisor to monitor and manage the diving operation, including any decompression requirement of the diver, and this is best achieved when using diving umbilicals coupled with pneumo hose and depth gauges on the dive control panel.

A dive computer or decompression meter is a device used by recreational and technical SCUBA diver(s) to measure the time and depth of a dive so that a safe ascent rate can be calculated and displayed so that the diver can avoid decompression sickness.

The dive computer tracks the dive profile by measuring time and pressure. All dive computers measure the surrounding pressure to estimate the partial pressure of gases in the human tissue. More advanced dive computers also include



Photo 13 : "H" valve.



Photo 14 : "Y" valve.

additional information into the calculations, for example, the water temperature or the diving cylinder pressure.

The computer then uses the profile and a decompression algorithm (a mathematical formula) to estimate the partial pressure of inert gases that has dissolved in the diver's tissues. Based on these calculations, the computer estimates when a direct ascent is no longer possible, and what decompression stops would be needed.

Different manufacturers use different algorithms so comparisons of dive profiles from one computer to another cannot be made.

The calculations made by the dive computers cannot be relied upon in all cases to help a diver avoid decompression sickness. The computer does not make calculations based upon what physiological events are taking place in the diver's body. Even if the diver follows the calculations made by the computer precisely, there is the possibility that decompression sickness will still occur. There are too many biologic variations in each dive for a dive computer to provide decompressions calculations that are 100% safe. Some of the variables that have been suggested to be associated with DCS:

- Water temperature;
- Work load during the dive;
- Amount of body fat in the diver's body;
- Consumption of alcohol prior to the dive;
- Fatigue prior to and during the dive; and
- Diver's age.

A diver wishing to reduce the risk of decompression sickness can take a number of precautionary measures such as:

- Use dive computers with a conservative decompression model;
- Use safety factors with dive computers (e.g. using a high altitude dive mode for a dive at sea level);
- Add additional deep safety stops during a deep dive;
- Make a slow ascent;
- Add additional shallow safety stops; and
- Have a long surface interval between dives.

This TA requires that a dive plan be established before the dive and then followed throughout the dive unless the dive is aborted. This dive plan should be within the limits of the decompression tables.

This increases the margin of safety, and also provides a backup decompression schedule based on the dive tables in case the computer fails underwater.

The main problem in establishing dive computer algorithms is that the gas absorption and release under pressure in the human body is still not completely understood. Furthermore, the

risk of decompression sickness also depends on the physiology, fitness, condition and health of the individual diver.

Dive computers are certainly a very effective tool for assisting scuba divers in determining their decompression liability, as long as the diver understands how to use the computer and the dive computer is programmed with conservative decompression algorithms.

5.2.6 First Stage Regulator

A first stage regulator is attached directly onto the bailout bottle/cylinder and is used to reduce high pressure air (approximately 3000psi/200bar) down to an intermediate pressure that is suitable for the second stage regulator, (about 147psi/10bar).

5.2.7 Personal Diving Equipment

When divers enter the water to carry out their tasks, along with their diving helmets and bail-out bottles, they will need their personal diving equipment. This will include the following items, plus any specialised tools required by the diver to carry out his work tasks.

Buoyancy Compensator Device (BCD) – this enables the diver to control his buoyancy, which is invaluable when working mid-water, or underneath ships hulls.

Heavy duty denim overalls – to protect the diver from cuts and abrasions when working around and on marine encrusted surfaces. (Note: Regular thick coveralls may also be used.)

Under-suits – in tropical waters these 1mm under suits give extra protection to the diver.

Wet suits – are of various thickness, and can be used in both tropical and temperate waters for diver warmth.

Harness – coupled with crutch straps - may be integrated with the BCD or the bailout bottle. Used to attach the diver's umbilical using a 'screw gate karabiner'. Can be used to attach small light items of equipment to and can also be used for emergency diver recovery.

Knife – these come in many shapes and sizes and tend to reflect the owner's preference. A diving knife **SHALL** always be carried by the diver. Some divers carry several knives.



Photo 15 : Divers bail out bottle first stage regulators.

Fins/boots – ‘Wellingtons’ are the boot of choice for bottom work. Diver’s fins are normally industrial strength ‘Jet’ type fins.

Gloves – may be Kevlar, leather or cotton, depending on the planned diving task.

Dry suit – to be used on an ‘as-required’ basis, but is not normally used in tropical waters.

5.2.8 SCUBA Replacement Package (SRP)

The Scuba Replacement Package (SRP) was developed to retain the mobility of SCUBA diving equipment while incorporating the safety features of surface supplied diving equipment. A typical SRP has 3 x 50L HP air cylinders (2 cylinders for the diver’s supply and 1 cylinder for the standby diver’s supply) mounted in a frame, which also incorporates an air supply panel and dive radio/communications unit.

The 2 x 45m (150ft) diver’s umbilical are stowed appropriately on the outside of the SRP frame. Although the SRP units shown in the photograph below are frame mounted, it is also common to break the equipment into individual components when working from isolated sites where vehicular access is not possible and the equipment must be carried into the work site.

The use of SRP provides all the safety aspects of surface supplied diving such as communications between the diver and diving supervisor suitable air supply and quantity coupled with back-up emergency air supply for the working diver and stand by diver, suitable depth monitoring of the diver by the diving supervisor and lifeline to the diver.

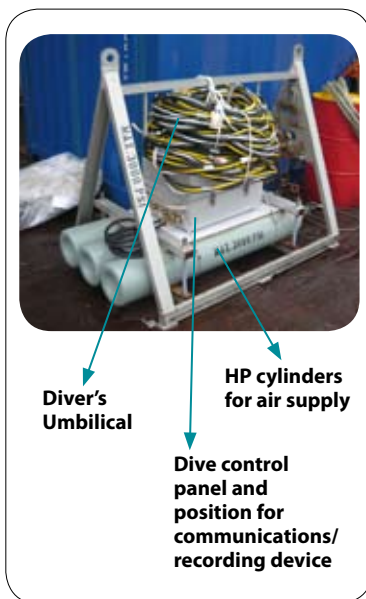


Photo 16: Typical SCUBA Replacement Pack.

5.2.9 Diver Access/Egress of the Water and Emergency Recovery of a Diver

Diving should only be carried out from a safe and suitable site or vessel/boat. There should be suitable means of access and egress for the divers. If using a ladder, the ladder **SHALL** have suitable hand support, suitable ladder rungs, extended below the water level by 2 metres and be provided with suitable hand hold for climbing from the ladder to the working deck area. (Normal construction ladders are not suitable for this purpose.)

There should be a means to recover an injured or distressed diver from the water. This may be by means of a platform mounted on the boat, use of a Jason’s Cradle or similar device or by a purpose built davit that is able to safely lift the injured/unconscious diver from the water into the boat.

5.2.10 Deck Decompression Chamber (DDC)

A decompression chamber is a pressure vessel used in diving to allow the divers to complete their decompression stops at the end of a dive on the surface rather than underwater. This eliminates many of the risks of long decompressions in the water, in cold or dangerous conditions.

Decompression chambers are known as Pressure Vessels for Human Occupation (PVHO), and as such, must be built to exacting standards and are normally certified by a Classification Society such as ABS, DnV, Lloyds etc.

Decompression chamber support is required for all diving operations and **MUST** be available or identified as outlined below.

For planned, no decompression dives shallower than 10msw (30fsw), emergency response procedures are to be in place to transport and treat a diver at the nearest available two compartment chamber, which should be no more than 6 hours travelling distance from the dive site.

For planned dives over 10msw (30fsw) and up to 50msw (165fsw), where there is no planned in-water decompression, or where decompression stops are planned for up to 20 minutes in the water, a two compartment decompression chamber is required within 2 hours traveling time from the work site.

For dives planned with in-water decompression greater than 20 minutes, or where a risk assessment requires a two compartment decompression chamber, then the two compartment decompression chamber is to be available for use on-site.

The DDC has to be manufactured to industry approved standards for pressure vessels for human occupancy, in-date for test, and be accompanied by a Certification Package which contains the manufacturing, maintenance and test details of the DDC.



Photo 17: Typical Air Diving Decompression Chambers (External and Internal).

5.2.11 Low Pressure (LP) and High Pressure (HP) Air Compressors

Both LP and HP air compressors may be used during an air diving operation. They all operate in a similar fashion, drawing in air at atmospheric pressure and compressing it to the desired final pressure. Such compressors **MUST** be purpose built and fit for purpose and where possible be oil free (i.e diving compressors that provide compressed air to the required purity standard; purity standard of diving air shall be the international standard BS EN 12021:1999).

Compressors are rated according to the volume of air that they take in each minute. This is the free gas volume of air that is delivered to the diver.

The supply pressure must be sufficient to get the air to the diver. At 50msw (165fsw), the maximum depth for air diving, the pressure is 6bar absolute. Allowing 10bar (145psi) for the regulator, the compressor supply pressure must be at least 16bar (235psi). Planned dives to shallower depths require less air supply pressure.

The LP air compressor is used to supply air via the dive control panel, directly to the diver through the diver's umbilical.

LP air from the air compressor is always supplied to an air receiver before being routed to the dive control panel and then on to the diver.

HP air compressors are used to charge the diver's bailout cylinders and HP air storage cylinders.

All compressors, both LP and HP have filter elements that remove water and oil mist from the compressed air.

All compressors must be included in the Planned Maintenance System (PMS). They must be regularly serviced, checked and tested for operability and air quality. Compressor Certification and operating logs must accompany each compressor to show that it is fit for service. Air purity tests must be carried out on a minimum of 6 monthly intervals.



Photo 18: Typical LP air compressor.



Photo 19: Typical HP compressor.

The air compressor purity test shall evaluate for the following substances:

• Carbon dioxide	not more than 500ml/m ³ (500ppm)
• Carbon monoxide	not more than 15 ml/m ³ (15ppm)
• Lubricant droplets/mist	not more than 0.5 mg/m ³
• Water	not more than 25 mg/m ³ (compressor outlet)

The diving contractor must be able to show by calculation that the LP air compressor is capable of supplying a sufficient volume of air to the diver(s) for the planned work activity.

Example: An LP compressor delivers 250 l/min at a pressure of 15 bar. One diver is planning to work at 20 msw. Is the air supply sufficient for both him and the standby diver?

An occupational diver is estimated to consume 35 litres (1.25ft³) of air per minute.

First, check the pressure at depth:

- Absolute pressure = $\frac{\text{Depth (msw)}}{10} + 1 \text{ bar}$
 $= \frac{20}{10} + 1 \text{ bar}$
 $= 3 \text{ bar}$
- Allow 10 bar for the demand valve:
- Pressure required = (3 + 10) bar
 $= 13 \text{ bar}$

The compressor delivers 15 bar, so the delivery pressure is suitable.

- Air consumption = Absolute pressure (bar) x 35 l/min
- Absolute pressure = 3 bar
- Air consumption = (3 x 35)l/min X 2 divers
 $= 210 \text{ l/min}$

The compressor delivers 250 l/min so the compressor delivery volume is adequate.

5.2.12 High Pressure (HP) Cylinders

HP air cylinders may be used as individual items, or, more commonly, may be supplied as a 'quad'. Quads are delivered in a protective frame that is normally fitted with lifting pad-eyes. Air quads can contain from 6 up to 64, 50 litres HP air cylinders connected together by pipe work and a manifold.

The air cylinders may be arranged so that half the bottles can be used as a primary air supply and half can be used as an independent, secondary air supply. The normal operating pressure for the 50 litres air bottle is 200bar, however, 300bar air cylinders are available. The working pressure of the cylinders must be checked as this has a direct affect on the actual air available. (Cylinders are made with differing working pressures in a range of 200 - 300bar).

On the worksite, the pressure of all the air cylinders must always be checked and logged as part of the pre-dive checks.

HP air cylinders must be supplied with in-date, 5 yearly hydrostatic test and an inspection certificate. When supplied by a third party company, a certificate of analysis showing that the air has been analysed for content must be included. Air cylinders must also be appropriately colour coded clearly identifying the cylinder (s) as 'diving air'.

The volume of air, the 'free gas volume', that the quad can hold is found by:

Free gas volume = floodable volume x pressure

Example: A 12 x 50 litre quad contains air at a pressure of 100 bar. What is the total volume of air in the quad?

- Free gas volume= (number of cylinders x floodable volume) x pressure
= (12 x 50) x 100
= 600 x 100
= 60 m³

5.2.13 Divers' Air Supply Volumes

The divers' air supply volume calculations should be based on a realistic dive plan, which includes getting down to working depth, getting back safely and having enough air in the event of an emergency.

A commercial diver is estimated to use 35 litres (1.25ft³) of air per minute. This is an average that can vary according to the workload and the diver.

During emergencies a breathing rate of 40 litres (1.5ft³) of air per minute is assumed.

The breathing rate of 35 litres is the free gas volume (FGV). This is the volume of air at surface pressure (1 bar). All gas volumes are measured at surface pressure.



Photo 20: Typical HP air quad.

If the diver is working at say 20msw, the absolute pressure is 3 bar. The free gas volume going through his lungs is 3 x 35 l/min, or 105 l/min (3.75 ft³).

- Diver gas consumption = absolute pressure x 35 l/min (metric)
- Diver gas consumption = absolute pressure x 1.25 ft³ (imperial)
- Absolute pressure = $\frac{\text{Depth (msw)}}{10} + 1 \text{ bar}$
- Absolute pressure = $\frac{\text{Depth (fsw)}}{33} + 1 \text{ atm}$

Example: A diver is working at 20 msw for 30 minutes. What volume of gas will he use?

- Absolute pressure = $\frac{\text{Depth (msw)}}{10} + 1 \text{ bar}$
 $= \frac{20}{10} + 1 \text{ bar}$
 $= 3 \text{ bar}$
- Gas consumption = Absolute pressure (bar) x 35 l/min
 $= 3 \times 35 \text{ l/min}$
 $= 105 \text{ l/min}$
- In 30 minutes, gas use = 30 x 105 l/min
 $= 3150 \text{ l}$
 $= 3.1 \text{ m}^3$

The diver will use 3.1 m³ of air (Note: Air volumes are normally worked in cubic metres).

If the diver is now working at 20 msw, breathing from a quad at a pressure of 100 bar, although the pressure is at 100 bar, the air is being supplied to the diver at 20 msw, where the pressure is 3 bar. That is 3 bar that is not available to the diver.

It also takes a certain amount of pressure (approx 10 bar) to operate the demand valve. That is another 10 bar that is unavailable to the diver. Altogether 13 bar is not available to supply the diver. The most that he can get out of the quad is 87 bar.

In practice, the diving supervisor would allow a considerable reserve pressure, and would normally change over to a new HP quad when the pressure drops to about 40 bar. In this case the available pressure would be (100 – 40) bar, or 60 bar. It is the available pressure that must be used in all calculations.

To find out how long the diver could work, use this formula;

$$\text{Time available} = \frac{\text{Gas available}}{\text{Gas consumption}}$$

Example: A diver is working at 20 msw, breathing from a 12 x 50 litre quad at a pressure of 100 bar. How long could he work? (Assume that the quad will be changed over at 40 bar)

- Floodable volume = 12 x 50 litres
= 600 litres
= 0.6 m³
- Available pressure = (100 – 40) bar
= 60 bar
- Free gas volume = floodable volume x available pressure
= 0.6 x 60 m³
= 36 m³
- Gas consumption = Absolute pressure x 35 l/min
- Absolute pressure = $\frac{\text{Depth (msw)}}{10} + 1$ bar
= $\frac{20}{10} + 1$ bar
= 3 bar
- Gas consumption = 3 x 35 l/min
= 105l
- Time available = $\frac{\text{Gas available}}{\text{Gas consumption}}$
= $\frac{36,000l}{105l/\text{min}}$
= 342 minutes

The diver has enough air available for 5.7 hours= 5 hours 42minutes.

The same calculation can be used if the diver is working with SCUBA.

Example: A diver is working at 20 msw, breathing from a 1 x 10 litre SCUBA cylinder at a pressure of 200 bar. How long could he work? (Assume that the diver will surface when the SCUBA pressure is 40 bar)

- Floodable volume = 1 x 10 litres
= 10 litres
- Available pressure = (200 – 40) bar
= 160 bar

- Free gas volume = floodable volume x available pressure
= 10 ltrs x 160 bar
= 1600 ltrs
- Gas consumption = Absolute pressure x 35 l/min
- Absolute pressure = $\frac{\text{Depth (msw)}}{10} + 1 \text{ bar}$
= $\frac{20}{10} + 1 \text{ bar}$
= 3 bar
- Gas consumption = 3 x 35 l/min
= 105 l/min
- Time available = $\frac{\text{Gas available}}{\text{Gas consumption}}$

= $\frac{1600 \text{ l}}{105 \text{ l/min}}$
= 15 minutes

The SCUBA diver has enough air available for 15 minutes, with a reserve of 40 bar to get him back to the surface.

The bail-out bottle is the diver's back-up in an emergency. The deeper he is, the less time he has.

The dive plan must include an assessment that the diver's bail-out has sufficient reserve for the planned diving task.

Example: A bail-out bottle has a floodable volume of 12 litres. How much time has a diver got if his surface supply fails at 20 msw.

The bail-out bottle is at a pressure of 180 bar. At 20 msw the pressure is 3 bar, add on 10 bar for the regulator and that is 13 bar that the diver cannot use.

- Available pressure = (180 – 13) bar
= 167 bar
- Free gas volume = floodable volume x available pressure
= 12 x 167
= 2004 litres

This is an emergency, so allow a consumption of 40 l/min. The absolute pressure is 3 bar

- Gas consumption = (40×3) l/min
= 120 l/min
- Time available = $\frac{\text{Gas available}}{\text{Gas consumption}}$
= $\frac{2004}{120}$
= 16 minutes

The diver has about 16 minutes of air available from his bail-out bottle.

5.3 Service and Maintenance of Equipment

All diving equipment must be subject to regular inspection, maintenance and testing in accordance with a Planned Maintenance System (PMS). The PMS should follow the manufacturers recommendations for the maintenance of the diving equipment and plant.

All maintenance and repair of diving plant and equipment must be carried out by trained and competent equipment technicians.

Technicians working on diving helmets, masks and regulators **MUST** have completed an appropriate maintenance training course at a training facility approved by the manufacturer for the equipment.

5.3.1 Planned Maintenance System (PMS)

A recommended schedule for maintenance of diving equipment is tabulated in Annex Q. As a minimum this periodic examination and testing **SHALL** be carried out by the owner of the diving equipment.

6. Different Diving Techniques and Procedures

This section outlines diving techniques, equipment and operational procedures that **SHALL** be considered when planning any diving operation.

6.1 Dive Planning

Before any diving operation is carried out there should be a diving project plan prepared for that operation. As a minimum the dive plan should cover the following aspects of the diving operation:

- The planned method of performing the task;
- The duties of every person involved in the task;
- The diving equipment to be used;
- Equipment check lists (pre-dive/post-dive);
- The breathing gases to be used, including the amount of breathing gas required;
- Safe deployment and recovery for diver and standby diver;
- The diving procedures to be used, including the planned bottom times and decompression profiles;
- Step by step work procedures;
- Equipment and tools for the work task;
- Specific task hazards and the measures to mitigate (reduce/remove) those hazards; and
- The Emergency Response Plan (what we do if things go wrong).

The following information provides data on the types of equipment that can be used to meet the minimum equipment requirements.

- Risk management process, consisting of onshore planning and work preparations; work site task execution, HAZID's/HIRA, JSA, Toolbox Talks, management of change;
- Management of change procedure;
- Safety management interface documents (bridging documentation) agreed by all parties;
- Diving operations manual;
- Diving equipment maintenance procedure;
- Mobilisation/demobilisation plans;
- Codes, standards and reference documents;
- Communications and organisation responsibility charts;
- Accident/near miss/incident notification, reporting and investigation procedures; and
- Permit to work system.

6.1.1 Dive Plan

The planned diving operation should be broken down into individual tasks. Each individual task, (that makes up the complete diving operation), is then further broken down into the steps that are necessary to complete each individual task. In this way, potential hazards can be identified and a risk assessment can be conducted.

For guidance on conducting the risk assessment, reference should be made to the Ministry of Manpower (MOM) Work Safety and Health Risk Management; Risk Assessment Guidelines in accordance with the Work Safety and Health Act (WSH Act) (Risk Management) Regulations 1 September 2006.

6.1.2 Environmental Considerations

Adverse weather conditions may affect the safety of a diving operation and the dive plan should identify the wind, wave, surface visibility, current and sea state levels above which diving should cease. In many instances the decision to stop or continue with diving operations will be a judgment call made by the diving supervisor.

Weather operating parameters are not based on the ability of a diver to continue working. They are determined by the ability of the dive team to safely start and stop diving operations (launch/recover a diver and dive boat), and also be able to see and safely recover a distressed diver.

6.2 Selection of Diving Techniques and Method

Diving methods and equipment **MUST** be determined as part of the risk assessment.

6.2.1 SCUBA Diving Technique

The term SCUBA is an acronym for Self-Contained Underwater Breathing Apparatus.

SCUBA is the preferred method of diving for the scientific/research community and recreational diving because it is most commonly used for entry level diving activities, it is relatively inexpensive equipment to purchase, it is light weight and highly mobile, it requires minimum support and maintenance and it is readily available 'off the shelf'.

The available air supply for a SCUBA diver is limited to the size of the tanks the diver can carry on his back. The full considerations for the use of SCUBA are outlined in paragraph 5.2.1; SCUBA must include an independent reserve air supply that should not be compromised if the primary air supply fails.

Scuba equipment should be used with a full face mask (for diver safety and comfort) and the SCUBA diver must be fitted with a lifeline.

The use of SCUBA diving equipment for occupational diving operations outlined in this TA **SHALL** be for exceptional circumstances only. A formal risk assessment **MUST** be carried out that identifies the reasons why surface supplied diving equipment can not be used as well as identifying the risks and mitigation of the risks using SCUBA for the operation. In the event SCUBA diving techniques are used for the occupational diving operation, the equipment used **SHALL** include that listed in paragraph 5.2.1 as a minimum requirement.

6.2.2 SSDE Diving Technique

Surface Supplied Diving Equipment (SSDE) is the diving method of choice for occupational diving operations.

With suitable planning and preparation this method of diving can be carried out from any location, jetty/dock side, small vessel/craft, jack up rig, power plant, water plant, lakes and reservoirs etc.

SSDE diving means that the diving supervisor can provide the diver with almost unlimited quantities of breathing air, there is a secured line attachment to the diver's harness, there are clear communications between the diver and diving supervisor, the diving supervisor can see the diver's activity (if the diver's hat camera is fitted) and record the diver's conversation during his dive.

It is normal to operate SSDE diving operations using an LP Compressor as a primary source of air with HP cylinders as the back up source of air supply, however it is also suitable to have several 50 litres HP air cylinders, which gives the diver an adequate primary and secondary air supply, however these could be of small cylinder size and be easier to move. In all cases the air requirements **MUST** be calculated and be sufficient for the dive duration and emergency back up. When using SSDE the diver should also wear a bail-out-bottle as his emergency air supply.

In the photographs below the diver is wearing a diving helmet, which both protects his head and allows clear communications with the diving supervisor. The diver is also wearing a hat light and a hat camera. It is often a requirement that a diver hat light/camera is used during air diving operations, for both the safety of the diver and to have a record of the diver's activities.

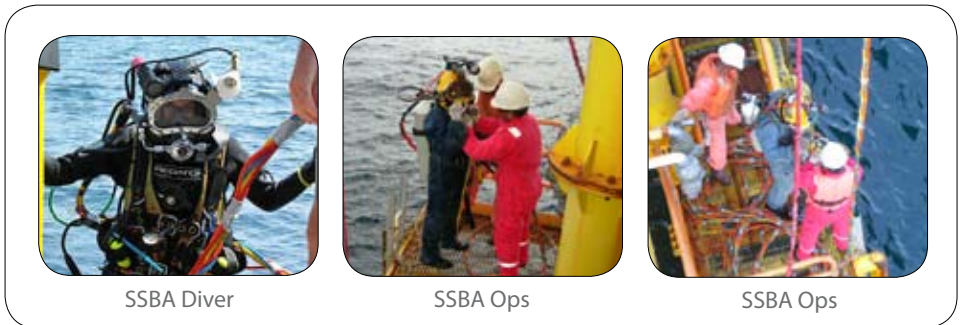


Photo 21: Demonstrating the use of Surface Supplied Diving Equipment.

Although SSDE diving requires more equipment than SCUBA diving, the resulting benefits to the diver (and the diving contractor and client) of safe, controlled and efficient diving activities far outweigh any supposed advantages from using SCUBA. The use of SRP equipment as outlined in Paragraph 5.2.8 provides the advantages of SSDE techniques in a portable mode of operation.

6.2.3 SCUBA - LifeLine Diving Technique

SCUBA lifeline generally refers to SCUBA diving where the diver wears a full face mask fitted with an integral communications unit. The lifeline is the combined communications/lifeline that is connected to the diver's harness, and is handled by the diver's attendant on the surface.

The communications/lifeline allows the diving supervisor to communicate with the SCUBA diver. In this most basic form the lifeline does not give the diver a surface air supply, or any other services.

6.3 Dive Team Size

The dive team size must commensurate with the planned diving operation. To have one (1) working diver in the water where the diving operation is in a benign location (aquarium, swimming pool), the minimum number of persons required **SHALL** be four (4), (supervisor, diver, attendant, standby diver).

In all other diving operations that have one (1) working diver in the water the dive team **MUST** be made up of at least 5 people, (supervisor, diver, diver attendant, standby diver, standby diver attendant). It may be that at least one other person is required to operate machinery or support the diving operation (i.e. technician or coxswain).

For every additional diver in the water, a diver attendant is required to attend to the diver's lifeline/umbilical.

There **SHALL** be one standby diver on the surface for every two divers in the water (Reference para 4.7)

All members of the dive team **SHALL** be trained and certified in First Aid.



Photo 22: Demonstrating the use of SCUBA with lifeline and communications line.

Note

Occupational diving using free swimming diving methods is not permitted under this TA.

7. Project Specific Equipment

The pre-dive planning meeting is used to determine the type of project tools and equipment that is best suited for the diving operation.

Equipment/tools that are required for the actual diving task will need to be reviewed to determine if the diver is able to carry them with him, or if the equipment is best deployed to the diver once he is established on the work site. In the case of heavy equipment or hand tools, provision will need to be made for buoyancy to the equipment prior to the tools being passed to the diver.

Working under ship hulls is especially difficult for divers as there are very few places to hang on to. 'Hogging' lines are often passed underneath ships to assist divers in maintaining their position when working around sea chests, or other hull intakes/discharge openings. Alternative means such as magnetic clamping devices can also be used when working in such circumstances.

Dams and culverts, with their smooth surfaces, can present great challenges to divers when they attempt to secure themselves in position to work with tools underwater.

8. Communications

8.1 Diving Signals and Flags

Whenever a vessel/small craft is engaged in diving operations the following shall be exhibited:

- Three all-round lights in a vertical line where they can best be seen. The highest and lowest of these lights shall be red and the middle light shall be white; or
- A rigid replica of the International Code flag “A” not less than 1 metre in height. Measures shall be taken to ensure its all-round visibility; or
- Three shapes in a vertical line where they can best be seen. The highest and lowest of these shapes shall be balls and the middle one a diamond.

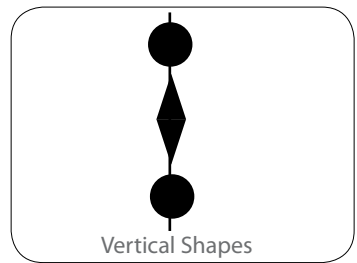


Image 1: Demonstrating the use of Flag Alpha and Vertical shapes.

8.2 Diving Line Signals

The primary means of communication between the diving supervisor and the diver will be via ‘hard wire’ communications. Line signals can be used as a secondary/emergency means to communicate with the diver, when the diver has a lifeline; umbilical that is attached to the diver’s harness.

All divers should be able to employ line signals for standby or emergency communication between the surface and the diver.

All signals from tender to diver are to be preceded by one pull to attract attention; the signal is then made after the diver has answered with one pull.

All signals received must be acknowledged by repeating the signal until a correct acknowledgement is received.

It must be remembered that a diver at work may not always be able to acknowledge a signal immediately, and the tender must wait a few moments before repeating the signal.

Foul Lines

If the lifeline gets turned around a down line it may be impossible to get signals through and the turns must be taken out from the surface as soon as possible. Umbilical management is the responsibility of the diver to ensure the line/umbilical is always clear and leads directly back to the tending point (surface). The diving supervisor should carry out regular checks during the course of the dive to ensure the diver's umbilical/line is not fouled. Reference paragraph 3.2.5.

Single Lifeline Signals

Attendant to Diver

General Signals

- 1 pull - To call attention; are you well?
- 2 pulls - Am sending down a rope's end (or as pre-arranged).
- 3 pulls - You have come up too far, Go down slowly till we stop you.
- 4 pulls - Come up.
- 4 pulls followed by 2 bells - Come up - hurry up, or, come up - surface decompression.
- 4 pulls followed by 5 bells - Come up on your safety float.
- 6 bells - Disconnect lazy shot/XBS, standby drifting stops.

Direction Signals

- 1 pull - Search where you are.
- 2 bells - Go to the end of distance line or jackstay.
- 3 bells - Face shot then go right.
- 4 bells - Face shot then go left.
- 5 bells - Come into your shot, or turn back if on a jackstay.

Diver to Attendant

General Signals

- 1 pull - To call attention; made bottom; left bottom, reached end of jackstay; I am well..
- 2 pulls - Send me down a rope's end (or as pre-arranged).
- 3 pulls - I am going down.
- 3 pulls 2 bells -Total LSE failure breathing from XBS demand valve.
- 4 pulls - I want to come up.
- 4 pulls followed by 4 bells -
- 4 pulls followed by 5 bells - May I come up on my safety float?
- Succession of pulls (must be more than 4 pulls) - EMERGENCY SIGNAL Pull me up IMMEDIATELY
- Succession of 2 bells - Am foul and need the assistance of another diver;
- Succession of 3 bells - Am foul but can clear myself if left alone.

Working Signals

- 1 pull - Hold on or stop.
- 2 bells - Pull up.
- 3 bells - Lower.
- 4 bells - Take up slack lifeline, or you are holding me too tight.
- 5 bells -Have found, started, or completed work I have commenced breathing oxygen (when carrying out stops).

9. Diving Support Locations

The location of where the diving operation is carried out from can vary, such locations include:

- Power plants
- Sewage systems
- Rivers
- Lakes
- Reservoirs
- Open water (sea)

Each of the above locations has their specific hazards that are to be considered during the dive planning stage. Considerations should be given to the following:

- Environmental;
 - Tides
 - Current (water flow)
 - Sea state
 - Fresh water/salt water
 - Altitude
 - Weather conditions
- Pressure differentials; when working in areas of dams, cofferdams, filter screens etc.; and
- Contamination; sewage systems.

9.1 Diving Platforms

A platform where a diving operation maybe carried out can include:

- Dock side or jetty;
- Small craft (7 m or less in length);
- Large craft (greater than 7 m in length);
- Jack up rigs; and
- Barges.

The diving platform should be:

- Of adequate size to accommodate the dive team and their equipment;
- Seaworthy and sufficiently stable to act as a diving platform;
- Well maintained, and where applicable, in-date for test;
- Equipped with appropriate safety equipment (including first aid and fire fighting equipment) suitable for the planned task;
- Equipped with appropriate equipment that commensurate for boat/craft of its size (anchor, radio, navigation lights, diving flag, engines, fuel reserves etc.);

- Provided with adequate protection from exposure (heat/cold); and
- Have a suitable platform/ladder for diver egress/access to the water/boat, for normal and emergency use.

Note

The practice of “live boating”, or diving from a vessel/boat while it is underway **MUST** not be carried out.

9.2 Equipment Mobilisation

There should be a mobilisation plan for all diving operations. Depending on the extent of the equipment used and/or how regularly the equipment is mobilised to the same location this plan maybe a generic plan that is reviewed during the mobilisation process or a more complex plan.

Once on site, each item of the diving equipment should be assembled and tested.

The pre-dive checklists (Reference Annex A,C,D and E), are used to ensure that all the equipment is checked and functionally tested before diving operations commence, are to be documented.

Confirmation that all the pre-dive equipment checks have been completed is logged in the Dive Sheet, and forms part of the official dive record.

10. Diving Operation

This section outlines diving operation and actions required during the dive.

10.1 Dive Briefing

Before commencing diving operations the dive team will need to be briefed. It is normal to hold a Project Briefing off site, however, for smaller diving operations the briefing could be by way of a Toolbox Talk on site.

This should include, but not be limited to:

- The objectives of the diving operation (what we plan to do and how we plan to do it);
- A review of the risk assessment;
- Equipment checks are completed and all fit for use;
- Operational environmental parameters, and the weather forecast;
- The Dive Plan (ie the discrete tasks required to accomplish the dive plan);
- The dive rota (the order in which people dive) and dive team personnel duties;
- Project safety precautions (what we are going to do to keep ourselves, and others, safe);
- Special safety considerations (anything extra-ordinary that may hurt us); and
- Emergency response (what we do if things go wrong).

Prior to each dive the divers' briefing should involve the standby diver for the dive, so that in the event of an emergency the standby diver will have an understanding of the work task being carried out.

10.2 Pre-dive Checks

The following checks **SHALL** be carried out prior to the diver entering the water

Standby diver 'checks' that he has:

- Checked emergency air supply is working and is of suitable pressure;
- Checked main air supply is on and working;
- Checked communications;
- Checked the umbilical is secured to the harness;
- Helmet/mask ready to put on immediately if required to enter the water; and
- Fins.

Diver 'checks' that he has:

- Checked emergency air supply is working and is of suitable pressure;
- Checked main air supply is on and working;
- Checked communications;
- Checked the umbilical is secured to the harness;
- Checked the helmet/mask is secure;
- Checked the diver's pneumo is available at chest level;
- A knife;
- Fins or boots, gloves, etc.; and
- Has tools for the work tasks.

Reference Annex A,C,D and E for sample template check lists.

Once the diver is in the water, check for leaks around the first stage regulator by observing for bubbles around the valve/bailout area. Provided no leaks are seen the diver can proceed to the work site.

10.3 Tending the Diver

The divers' attendants are normally trained divers, who act as dive tenders as part of their duties.

The attendant (tender) helps the diver to get dressed, checks the diver's equipment once he is dressed and assists the diver to the ladder/water entry point.

Once the diver is in the water the tender handles the diver's umbilical, ensuring that the correct amount of tether is given to the diver. The diver's umbilical must be held firmly, but not taut. The diver must be able to move freely without feeling constrained by his umbilical, but there should not be an excessive amount of umbilical in the water. The tether can easily become fouled/entangled if this occurs. Equally, the tender must be able to respond to signals from the diver when given through his tether.

10.4 Ascent

When the dive task is completed or the maximum time for the dive at the depth has been reached the diver will return to the surface, the diver shall ascend at a rate in accordance with the diving tables being used, normally about 10 m (30 fsw) per minute.

For a normal ascent the diver should breathe steadily and naturally. This is very important. A diver **MUST** never hold his breath during ascent because of the danger of suffering a lung over expansion injury.

It is also good practice for the diver to ascend with an arm extended overhead. In the murky waters normally encountered in harbours and inland waterways, the diver must always be careful of obstructions and potential overhead hazards.

Prior to the diver leaving the worksite the diver will request the tender to come up on his

umbilical until it is pulling against his harness. This will ensure that the umbilical is not fouled on any subsea structure.

It is normal for the tender to hold the diver's umbilical and for the diver to 'climb'/follow his umbilical back to the surface. During which time the diver tender **SHALL** recover the umbilical in as it becomes free to do so.

10.5 Post-Dive Procedures

Once the diver has been recovered from the water he should:

- Confirm with the dive supervisor that he is feeling well;
- Remove his diving equipment (aided by the tender); and
- Confer with the dive supervisor and de-brief the dive activities while the information is still fresh (lesson learned from each dive).

Meanwhile the dive team will:

- Thoroughly clean the mask mouthpiece with a mild sanitizing solution, then flush with fresh water;
- Check if any items of the dive equipment need maintenance;
- Charge the bail out bottle, if necessary;
- Check the status of the HP air supply cylinders;
- Carry out post-dive equipment checks; and
- If another dive is to take place on the same worksite, the diver will brief the next diver on the status of any tools/equipment that is still onsite (this is normally in conjunction with the dive supervisors briefing).

11. Organisation, Planning and Records

This section outlines organisation and planning requirements that **SHALL** be considered when planning any diving operation.

11.1 General

All diving operations involve a level of risk.

A diving operation should only be carried out after the all hazards have been identified, the hazard risks have been assessed by competent person or persons, and suitable measures to control/mitigate those risks have been determined and implemented. The risk assessment team should include at least one diver from the dive team.

Diving operations shall be organised and planned such that:

- Divers are suitably trained, certified and competent (experienced) for the planned diving task;
- The diver is briefed before he commences his dive;
- The size of the dive team is suitable for the planned diving operation;
- The dive team is familiar with the risks associated with the planned dive activities;
- The dive is planned to give minimum exposure to the diver; and
- The dive team is familiar with, and has checked the Emergency Response Procedure.

11.2 Diver Registration / Training Matrix

Certain 'core competencies' are considered essential to personnel working as divers, and it is normal to list the members of the diving team, and their training qualifications in the form of a matrix (Reference: Annex F for sample template of training record matrix).

All divers and diving supervisors must retain personal documentation that demonstrates that they have completed diver training by an accredited organisation.

Diver training certification must be verifiable by diving contractors (by contacting the training establishment). It is the diving contractor's responsibility to ensure that the dive team personnel are competent to carry out the task for which they have been employed.

There are numerous instances of people presenting false diver credentials in order to gain employment as divers.

Divers must be able to present original copies of:

- A Diver Training Certificate issued by an accredited organization;
- Valid Certification confirming training in First Aid to an acceptable standard; and
- A valid diver medical certificate issued by a diving doctor.

11.3 Dive Proposal and Recording

Where diving activities are planned for areas or locations controlled by 'area authorities' such as Port Authorities and such-like, it is normal for those authorities to receive a Dive Proposal from the diving contractor before allowing any diving activities to commence.

The Dive Proposal will consist of the diving procedure, the diving project plan and the dive team training matrix, which will detail the entire diving operation, from planning through to mobilisation, to project completion.

The diving procedure and the diving project plan will also cover the emergency contingency and response procedures, and any support required from the 'area authorities'.

It may be that the 'area authorities' will require further specialist training for the dive team members before approving the Dive Proposal.

Invariably, a Dive Proposal will result in meetings with representatives of the 'area authorities'. It is advisable to prepare for these meetings by having drawings, diagrams and photographs available to support the request for permission to carry out the planned diving operation.

11.3.1 On Site Pre-dive Plan and Risk Assessment

Once the dive team has mobilised to the dive site, the dive plan and the risk assessment will need to be checked again by all the members of the dive team to confirm that the all items listed are still relevant, and to include new items not raised during the initial risk assessment.

It is normal to carry this action out by using a Toolbox Talk, prior to commencing diving activities.

Toolbox Talk Risk Identification Cards, (which are a valuable aide-memoir), come in many guises. One example is shown in Annex I.

The dive plan must emphasise that each and every member of the dive team has the right and the duty to stop the job if they believe that it is hazardous to commence, or to continue with the diving operation.

11.3.2 Diver's Record and Employer's Record of Dives

Diver's Log Books are available from organisations such as ADCI, IMCA or the Professional Diving Association (Australia). Diver's Log Books must carry a photograph of the diver. There is also provision in the front of each log book for the diver's medical details.

The following details should be included in the diver's daily record (log):

- Name and signature of the diver;
- Date of the dive;
- Name and address of the diving company;
- Name and signature of the diving supervisor for that dive;
- Location of the diving project;

- Name of the diving vessel (where applicable);
- The maximum depth reached on each occasion;
- The time the diver left surface, the bottom time and the time the diver reached the surface;
- The breathing apparatus and the breathing mixture;
- The decompression schedule followed by the diver;
- Any work done by the diver;
- Details of any injury/DCI suffered by the diver;
- Any incident of special note that occurred during the dive; and
- Company stamp.

All diving contractors should have dedicated, pre-printed Diving Operations Logs. The following details should be included in the Diving Operation Log (a sample template of dive record sheet can be found in Annex M):

- Name and address of the diving company;
- Date of the entry;
- Name(s) of the dive supervisor(s);
- Location of the diving operation;
- Name of the diving vessel;
- Names and duties of those taking part in the diving operation;
- The diving regulation that applies to the diving operation;
- The purpose of the diving operation;
- The breathing apparatus, the breathing mixture and pressure used by each diver;
- Time at which the diver leaves the surface, the bottom time and the time the diver returns to the surface;
- The maximum depth each diver reaches;
- The decompression schedule for each diver;
- Emergency support arrangements;
- Any emergency or incident of special note which occurred during the diving operation, including details of any decompression illness and the treatment given;
- Details of the pre-dive inspection of all plant and equipment used in the diving operation;
- Any defect recorded in the functioning of any plant being used in the diving operation;
- The weather during the diving operation;
- Any other factors likely to affect the safety or health of any persons engaged in the diving operation; and
- Name and signature of the supervisor completing the record.

11.4 Dive Procedures

11.4.1 Hazards for Diving Operations

Diving methods, equipment and hazards should be determined as part of the risk assessment.

The following conditions may lead to restrictions being imposed on the diving operation:

- Reduced or impaired surface and sub-surface visibility;
- The presence of contaminants in the water, or around the dive site;
- Obstructions, both above and below water;
- The presence of dangerous marine life;
- Strong currents;
- Working near water intakes and/or discharges;
- Pressure differentials- pipe lines, dams, cofferdams etc.;
- Lifting operations being undertaken on/near the dive site;
- Vessel movements around the dive site;
- Environmental considerations, such as monsoon weather; and
- Night diving.

11.4.2 Diving at Night

One aspect of night diving operations is restricted surface visibility. Diving operations to be carried out during the hours of darkness (or restricted visibility) will need to be the subject of a specific risk assessment and will require suitable surface lighting of the work site to ensure there are no 'dark areas'.

SCUBA and SSDE divers operating at night will require a diver's hat light and may need to wear an indicating or flashing strobe light, or some other type of safety light and personal location beacon.

12. Use of Decompression Tables

This section outlines the decompression requirements that **SHALL** be considered by all diving contractors for implementation within the company operations manuals and diving operations.

The contractor **SHALL** be responsible for ensuring that only industry approved occupational diving decompression tables are used for occupational diving operations. (Note: Recreational and technical diving decompression tables are not acceptable for use under this TA.)

There are at least two readily available and widely used sets of decompression tables in use in occupational diving. They are the USN Air Diving Tables, (available on the USN website), and the Defense and Civil Institute of Environmental Medicine (DCIEM) Diving Tables (Canada). The DCIEM Diving Manual is available for purchase.

Both sets of diving tables are available in either metric (msw) or imperial (fsw) versions, and come with explanations for their use.

Many diving contractors apply simple rules when using of the diving tables to enhance diver safety.

One such rule is for the diving supervisor to select the next longer decompression schedule than the one that would be normally selected. This can either be the next bottom time or depth or a combination of both. This is an effective way of increasing the decompression safety parameters for the diver. The decompression table to use and procedure for use **SHALL** be clearly identified in the diving contractor's diving operations manual and in the project dive plan.

Where possible for diving within the scope of the TA – No decompression diving should be planned. Reference Maximum Bottom Times in Annex J.

13. Underwater Emergency Procedures

This section outlines emergency considerations and requirements that **MUST** be considered when planning any diving operation.

13.1 Loss of Primary Air Supply

13.1.1 SCUBA Equipment Loss of Primary Air Supply

The SCUBA diver has a limited quantity of air available for his use. He must always be aware of his remaining air supply by constantly monitoring his contents gauge.

If a SCUBA diver loses his primary air supply he must immediately switch over to his secondary/emergency air supply, which may be a second cylinder that the diver was equalising from, or a pony cylinder.

Once the diver is on his secondary air supply he must immediately begin his ascent to the surface in a controlled manner. The diver should signal to the tender that he is surfacing. Using the communications, the diver should inform the dive supervisor of his status and his intentions.

13.1.2 SSDE Loss of Primary Air Supply

If the SSDE diver loses his primary air supply he must inform the diving supervisor, at the same time the diver should open his bailout emergency supply valve and commence breathing from the bailout. The diving supervisor will immediately open an alternative/emergency air supply on the supply panel. The dive **SHALL** be terminated by the diver returning to the surface, on his emergency air supply, by following his umbilical back to the surface.

It is unusual for equipment failure to cause a SSDE diver to lose his primary air supply, and the loss of the diver's air supply maybe caused by a trapped or severed umbilical.

In all instances of a loss of the diver's primary air supply, an investigation will need to be carried out to determine the cause of the air loss, and the actions required to prevent a reoccurrence.

In instances of a loss of the diver's primary air supply, the standby diver may be required to enter the water to assist the diver.

13.2 Entanglement

The possibility of diver entanglement should be determined as part of the risk assessment process.

Any diver can become entangled or fouled during diving activities. The entanglement may be on a mooring line, propellers, wreckage, debris, natural bottom formations, fishing lines or man-made structures, and the entanglement can be exacerbated by poor visibility and disorientation.

If the entanglement occurs when using SCUBA equipment, near the end of his dive, the diver's

air supply may be too limited for a lengthy untangling procedure. This is one of the reasons for planning for the diver to return to the surface with 500 psi (34 Bar) remaining in his tank.

If the diver or his umbilical becomes entangled, he should:

- Stop;
- Remain calm;
- Think;
- Signal the tender/inform the dive supervisor of the problem;
- Follow the umbilical back along to the entanglement; and
- Attempt to free himself.

The decision to deploy the standby diver to clear the fouled tether/diver will be made by the dive supervisor after he has reviewed the situation and assessed all the options available to him.

The pre-dive briefing should strongly discourage divers from disconnecting the umbilical and swimming freely to the surface. The risk of a second diver entanglement can never be discounted, and once the diver has released his umbilical his position becomes unknown and the ability of the standby diver to assist him becomes very difficult.

Correct umbilical management by the diver by knowing where the umbilical leads to at all times, and by the tender so that he can 'feel' the diver at all times, will reduce the possibility of entanglement.

13.3 Loss of Communications

The procedure to be employed when a diver loses communications should be discussed at the pre-dive briefing. In the event that communications with the diver is lost the diver should immediately terminate the dive, and signal the tender that he is leaving bottom.

When the dive supervisor realises that he has lost communications with the diver he should instruct the tender to signal the diver to 'come up' using line pulls.

The decision to deploy the standby diver to assist the diver maybe carried out after the diving supervisor has reviewed the situation and assessed all the options available to him.

14. Emergency Management

14.1 Incident Reporting and the Requirement to Report an Incident

The diving company must have a documented procedure for Incident Reporting and Recording in accordance with the WSH Act. The Client Company may also have an Incident Reporting requirement. Every incident should be reported and recorded immediately, with the level of follow-up action to be determined by the seriousness of the incident and by the diving company management. An example of an Initial Incident Report form is referenced in Annex R. Note: All reportable incidents **MUST** be reported in accordance with the WSH Act.

14.2 Emergency Procedures and Contacts

The Diving Contractor's Emergency and Contingency Manuals should include flowcharts that will indicate the process for dealing with diving emergencies. These flowcharts are generic in nature, therefore specific emergency contact checklists will need to be generated for each diving worksite. A sample of a contact list is referenced in Annex S and a sample of a Emergency Flow Chart is referenced in Annex K.

14.3 Emergency Recovery of a Diver

When carrying out diving operations there must be a system for recovering a distressed/injured diver back into the diving site platform/location. This diver recovery method must not expose the surface personnel or diver to an elevated risk of incurring personal injury during the recovery process.



Small boat dive ladder



Diver recovery davit

Photo 23: Illustrates a diving ladder and a dedicated diver recovery davit. Ladders and diver recovery davits must be properly designed, built and load tested.

Annex A: Sample Checklist for Site Owner (e.g MPA/PSA) and/or Diving Contractor for Immediate Use

The following Diving Permit to Work Checklist may be used by site owners or clients prior to commencing diving operations. Although diving contractors are directly responsible for the safety and health of all their personnel, site owners and clients also have a responsibility through their acts or omissions for the safety of personnel during a diving operation.

Site Owner / Client Diving Operations Pre-Dive Hazard Checklist		Circle as necessary	
1. Risk Assessment			
Has a Diving Project Risk Assessment been completed for this diving project?		Y	N
Have the diving personnel reviewed and signed off on the Risk Assessment?			
2. Permit to Work			
Is a Permit to Work required for this diving activity?		Y	N
Is a copy of the Permit to Work displayed on-site?			
3. First Aid Requirements			
Is a First Aider available?		Y	N
Is First Aid kit available?		Y	N
Is the First Aider qualified to the minimum standard?		Y	N
Is the First Aider training still valid?		Y	N
4. Personal Protective Equipment			
Do all the project personnel have PPE?		Y	N
Are any specialist items of PPE required for this task?		Y	N
List:.....			
5. Are There Any Other Hazards not Listed in the Risk Assessment			
Working at Height		Y	N
Working in a Confined Space		Y	N
Chemical/Contamination Hazard		Y	N
Inlets / Discharges		Y	N
Radioactive Sources		Y	N
Asbestos		Y	N
Other:.....		Y	N
6. Manual Handling			
Have the personnel been instructed in correct manual handling techniques?		Y	N
		Y	N
7. Has a Toolbox Talk been Completed?			
		Y	N
8. Is a Diver Competency Matrix Available?			
Is it in-date?		Y	N
Have the diver's training certification been checked?		Y	N
Have the diver's medicals been checked?		Y	N
9. Has the Port Authority Approved the Diving Operation?			
		Y	N
10. Worksite Check			
<ul style="list-style-type: none"> Is a copy of the work procedures available on site? All the diving equipment appears to be in working order. The diving equipment Certificate Register is available for inspection. A copy of the latest weather forecast is available. "Diver at Work" signs are displayed as appropriate- Flag Alpha. There are no crane operations in progress nearby. There is no scaffolding ongoing nearby. All inlets / discharges have been secured - lock out / tag out. All engines / propellers/ rudders have been secured - lock out / tag out. Is the site clear of falling objects? Have primary means of communication been tested? Have secondary means of communication been tested? Where appropriate, has all Marine Traffic been notified of the planned diving operations? Have all the boat checks been completed? Is the boat Emergency Survival Kit in the boat? 		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
		Y	N
11. Are all the Controls in Place?			
		Y	N
12. Signatures:			
Site Owner/Client Representative:		Date:	
Diving Supervisor:		Date:.....	

Annex B: Sample Signage “DIVERS AT WORK” for Immediate Use

Laminated signs marked “DIVER AT WORK” are to be available as part of the diving contractor’s equipment inventory. These signs are to be displayed on bridges/engine rooms, intake valves, discharges and any other location where the operation of machinery may be hazardous to divers.



Annex C: Sample Checklist for Diving Company/Contractor/Diving Supervisor for Immediate Use

	Pre-Dive Check Description	Check
1.	Is the PTW in place? PTW Number:	Y/N
2.	“Diver Down” board placed close to the main engine starting device and to bridge control panel	Y/N
3.	All vessel seawater intakes located and divers advised	Y/N
4.	All vessel thrusters secured- lock out / tag out	Y/N
5.	Vessel main engine port and starboard secured – lock out / tag out	Y/N
6.	Vessel steering motors secured –lock out / tag out	Y/N
7.	Watchkeeper standing by on bridge at all times during diving operations	Y/N
8.	Diving flag / signs displayed	Y/N
9.	Vessel diving PTW in place and valid	Y/N
10.	No bilge to be pumped or material dumped overboard	Y/N
11.	No dumping of food scraps	Y/N
12.	Weather forecast obtained	Y/N
13.	Weather and mooring arrangement reviewed prior to diving	Y/N
14.	Dive boat fully functional	Y/N
15.	Weather and sea state is suitable to carry out the diving operation	Y/N
16.	No other vessel to approach within 500 m of the diver	Y/N
17.	JHA for dive boat operations carried out	Y/N
18.	All tools on and above worksite to be secured during diving	Y/N
19.	Dive equipment operational and checked	Y/N
20.	Cables, hoses, whips and umbilicals to be kept tidy and to a minimum length	Y/N
21.	All communications to be tested prior to diving. Alternative means of communication and command to be considered	Y/N
22.	JHA and Toolbox Talk for diving operations carried out	Y/N

Declaration

Diving Supervisor

I understand that the work will only take place when all the above safety precautions are complied with.

Name _____ Signature _____ Time _____ Date _____

Completion Certificate (Dive Supervisor)

I declare that the underwater work specified above has been completed/not completed and all underwater equipment has been recovered and the diving site has been left safe.

Diving Supervisor:

Name _____ Signature _____ Time _____ Date _____

Annex D: Sample Diver Pre-dive Checklist for Immediate Use

No.	Item	Action	Check
1	Communication between the diver and dive control radio	Ensure the diver communications system is working	Y/N
2	Black box recording device	Ensure it is on and working. Start recording dive from dive checks to end of the dive	Y/N
3	Mask/helmet attachments, spider and hood liner, face mask strap	Inspect for corrosion, wear, tear or damage	Y/N
4	Mask/helmet non-return valve	Check for correct operation	Y/N
5	Mask/helmet air supply	Check that air is available on demand and also free flow	Y/N
6	Diver weight belt	Check for corrosion or damage. Ensure correct amount of weight for the diver	Y/N
7	Diver harness	Check for tear or damage. Fitted with crutch straps and a lifting 'D' ring	Y/N
8	Boots/fins and gloves	Check for damage and ensure it is a correct fit	Y/N
9	Knife and scabbard	Inspect knife for corrosion, damage and sharpness. Knife is positioned within easy reach of the diver's hands	Y/N
10	Torch/hat light/camera	Function check	Y/N
11	Umbilical safety carabina	Inspection for corrosion and damage. Check for operation and if secured to diver's harness	Y/N
12	Bail-out cylinder	Check contents pressure. Check correct operation to helmet/mask	Y/N
13	Air/as quad valves	Ensure the quad valves are fully open	Y/N
14	Air/gas supply	Check air/gas is supplied to the diver's helmet/mask. Check the reserve supply is available	Y/N
15	Tools	Ensure the necessary tools are available and in good condition. Fitted with a securing lanyard	Y/N
16	Diver overalls	Complete with full length sleeves. A light-weight, 'Lycra' under-suit to be worn	Y/N

Note: The diving supervisor notes in the Dive Log that the diver's pre-dive checks have been completed

Annex E: Sample Checklist for Diver’s Attendant for Immediate Use

No.	Action	Check
1.	Diver coveralls correct, under-suit worn	Y/N
2.	Diver harness fitted and secured	Y/N
3.	Diver bail-out fitted. On at the bottle, off at the hat/ready for use	Y/N
4.	Diver bail-out contents gauge readingbar	Y/N
5.	Diver helmet/mask fitted, safety pin in	Y/N
6.	Diver umbilical/lifeline secured to his harness and checked	Y/N
7.	Diver breathing from his gas supply	Y/N
8.	Diver has a knife	Y/N
9.	Diver weight belt secured	Y/N
10.	Diver tools attached to his harness	Y/N
11.	Diver gives OK and ready to dive	Y/N
12.	Diver understands his task, has been briefed and is ready for the water	Y/N

Declaration

Diving Supervisor

The above checks have been carried out and the diver is ready for the water.

Name _____ Signature _____ Time _____ Date _____

Annex F: Sample Diver Register/Training Matrix

The following Diver Training Matrix format may be used as a checklist to show that the members of the dive team are in possession of valid documentation which is suitable for the task for which they have been employed.

Name	Position	Years of Diving Experience	Qualification	Issue Date	Expiry Date	Certificate Number	Issuing Authority
			Medical Dvr Training SCUBA SSBA Other First Aid Survival PTW Course Other				

Annex G: Sample Dive Operations Manual Contents

There will be a Diving Operations Manual that will outline the procedures of how the diving contractor operates. The content of such an operations manual should be, but not limited to the following outline:

Diving Operations Manual Table Of Contents

<ul style="list-style-type: none"> 1.0 INTRODUCTION 1.1 Purpose 1.2 Abbreviations 1.3 Reference Documents 1.3.1 Project Specific Documents 2.0 Legislation, Standards and Guidance Notes 2.1 Legislation 2.2 Standards/Approved Code of Practice 2.3 Client Guidelines 3.0 Communication 3.1 Organisation Chart 3.2 Roles and Responsibilities 3.2.1 Client 3.2.2 Client Site Representative (CSR) 3.2.3 Diving Contractor 3.2.4 Diving Superintendent / Diving Supervisor 3.2.5 Divers 3.2.6 Tenders 3.2.7 Technicians 4.0 Diving Operations 4.1 General 4.2 Equipment 4.3 Depth Limitation 4.4 Air Decompression 4.5 Decompression Illness and Decompression Tables 4.6 Minimum Gas Requirements 4.7 Medical Equipment 4.8 Diving Operations 5.0 Dive Boat Mooring Procedure 6.0 Diving Umbilicals 6.1 Safety Principles 6.1.1 Point of Tending 6.1.2 Standby Diver 7.0 Environment 7.1 Visibility (Topside) 7.2 Sea-State 7.3 Weather 7.4 Tide Tables 7.5 Effects of Current Conditions on Divers 8.0 Simultaneous Operations 8.1 General 9.0 QHSES Management System (NOTE This maybe a separate manual which details the management system) 9.1 Objectives 9.2 QHSES Management System Documentation 9.3 Risk Management 9.3.1 Risk Assessment 9.3.2 Job Hazard Analysis Review 9.4 Accident and Incident Reporting 	<ul style="list-style-type: none"> 9.5 On-going Hazard Observation 9.6 Project Dive Team Familiarisation 9.7.1 General 9.7.2 Additional Training 9.7 Hazard and Effects Management 9.7.1 Physiological Affects 9.7.2 Physical Environment 9.7.3 Procedural Hazards 9.7.4 Breathing Gases 9.7.5 Medical Physiological Considerations 9.8 Personal Protective Equipment 9.9 Alcohol and Other Drugs 9.9.1 Use or Possession of Illegal Substances at the Worksite 9.9.2 Use or Possession of Alcohol at the Worksite 9.9.3 Use or Possession of Therapeutic Medication at the Worksite 9.10 Operational Safety 9.10.1 Job Hazard Analysis Meeting 9.10.2 Equipment Checks 9.10.3 Documentation 9.10.4 Personnel 10.0 Mobilisation and Pre-Commencement 10.1 General 10.2 Personnel Competency Assurance 10.3 Personnel Competency 10.4 Personnel Resources for Mobilisation 10.5 Equipment Resources 10.6 Dive Boat Resources 10.7 Diving Spread Worksite Installation 10.8 Equipment Lifting and Certification 11.0 Daily Operations 11.1 Safety Representative 11.2 Pre-start Toolbox Meetings 11.3 Equipment Inspections 11.4 Material Handling and Storage 12.0 Permit to Work 12.1 PTW Procedure 12.2 Diver Down Sign 12.3 Tag Out / Lock Out 13.0 Contingencies 14.0 Emergency Procedures (NOTE This maybe a separate manual) 14.1 Objectives 14.1.1 General 14.1.2 Emergency Contact List 14.2 Severe Weather Procedures 14.3 Alert and Call-out Procedures
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Annex H: Sample Job Hazard Analysis

Job Hazard Analysis Example

Diving Company Logo here		Job Hazard and Risk Assessment (JHA) WORKSHEET		JHA No:		JHA- XXX	
Area of Work / JHA Title:		LAUNCH AND RECOVERY OF WORK BOAT					
Last Updated By:				Last Updated On:			
Job Step	Hazards Identified	Controls & Checks Required				Action By	
Rig Up and Launch the Boat	Poor Weather Conditions Personnel injury Rigging Failure Launch Position Asset Damage	Lee to be provided when possible Monitor weather conditions, obtain weather forecast. Good communications and awareness Correct PTW for over the side operations				Deck Foreman Deck Crew	
Personnel Transfer to Boat	Falling from Heights Falling Objects Poor Visibility Pinch Points Work Boat Movement Crush Injuries	Correct PPE to be worn at all times as stated on PTW Deployment area to have adequate lighting at all times During night time operations or in limited visibility personnel to wear personal EPIRBs and carry light sticks Weather limits to be monitored Good communications during boat launch				Deck Foreman Deck Crew	
Type of Permit Required (please indicate by ticking box)		Additional PPE Requirements (Please list)		Special Tools or Equipment Required			
Diving		1)		1)			
Hot Work		2)		2)			
Confined Space		3)		3)			
Isolation / Electrical		4)		4)			
Working at Height		5)		5)			
REVIEW / UPDATE RECORD							
Participants	DATE	JHA Updated	Participants	DATE	JHA Updated	Participants	DATE

Annex I: Sample Template for Toolbox Talk Checklist

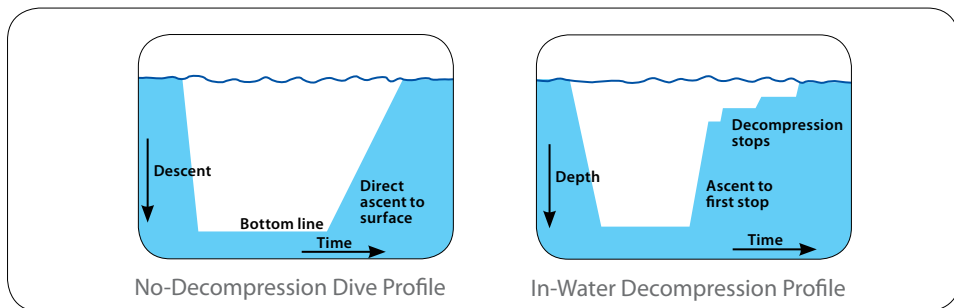
Hazard/Risk Management	Hazard/Risk Management	Toolbox Talk Risk Identification Card						
<p>Can all personnel in the group answer YES to the following questions?</p> <p>Have all the significant hazards involved with the work been identified?</p> <p>Have control measures been identified for these hazards?</p> <p>Have the people responsible for implementing these control measures been identified and are the controls in place?</p> <p>Has the method of communication been agreed and tested?</p> <p>Is everyone aware of what is being done at the worksite?</p> <p>Does everyone know that any changes to the work plan have to be communicated to everyone involved in the work?</p> <p>Does everyone know that any new people joining the work party must be given a full and thorough handover?</p> <p>If the answer to any of these questions is NO, then the safety of people is at risk.</p> <p>The talk leader should confirm the understanding of the group by asking open questions on the above points.</p>	<p>Will the work involve:</p> <p>The use of lifting equipment?</p> <p>Working in noisy areas?</p> <p>Line breaching or potential hydrocarbon release?</p> <p>Environmental impact?</p> <p>Manual handling-moving objects/ loads? (if yes, obtain/complete a manual handling assessment)</p> <p>Working near objects that may move?</p> <p>Working in an area with poor lighting or a tight/confined space?</p> <p>Working at height?</p> <p>Working near areas that could cause personnel to slip, trip or fall?</p> <p>Using portable electrical equipment?</p> <p>Working with equipment or connections under pressure?</p> <p>Working with dangerous goods and substances hazardous to health?</p> <p>Personnel who are new to each other?</p> <p>Equipment which is potentially dangerous?</p> <p>Pressure differentials?</p> <p>If so the work may be hazardous and care should be taken to ensure that the work is done safely.</p> <p>Remember, everyone is responsible for:</p> <ul style="list-style-type: none"> • Using the correct tools for the job. • Being aware of the hazards around them and remaining vigilant to change. • Using the correct PPE for the job. • Making themselves aware of, and working within the requirements of the PTW system, Procedures, Risk/COSHH/Manual Handling Assessments. 	<p>Location _____</p> <p>Worksite _____</p> <p>Talk Leader _____</p> <p>Dive Supervisor _____</p> <p>Task _____</p> <p>Date and Time _____</p> <p>Attendees</p> <ol style="list-style-type: none"> 1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____ 9. _____ 10. _____ <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>Reviewed by:</p> <p>Talk Leader _____</p> <p>Dive Supervisor _____</p> </div> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>Action Required:</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 70%;">Update Procedures</td> <td style="text-align: right;">Y/N</td> </tr> <tr> <td>Update RA</td> <td style="text-align: right;">Y/N</td> </tr> <tr> <td>Other</td> <td style="text-align: right;">Y/N</td> </tr> </table> </div>	Update Procedures	Y/N	Update RA	Y/N	Other	Y/N
Update Procedures	Y/N							
Update RA	Y/N							
Other	Y/N							

Annex J: Sample Decompression Procedures

The diver's decompression procedures will follow those laid down in the Diving Tables used by the diving contractor. The two diagrams below show a No-Decompression Dive Profile and an In-Water Decompression Dive Profile.

The DCIEM Diving Manual has each depth segment divided into two sections by a double line which indicates the Normal Air Diving Limit. Dive profiles below this line are considered Exceptional Exposures.

Exceptional Exposures should only be used under exceptional circumstances and only in conjunction with Surface Decompression with Oxygen in an on-site DDC.



Repetitive diving operations are permitted in accordance with the instructions and guidelines within the USN and the DCIEM Diving Tables. Under this TA repetitive diving should not be planned.

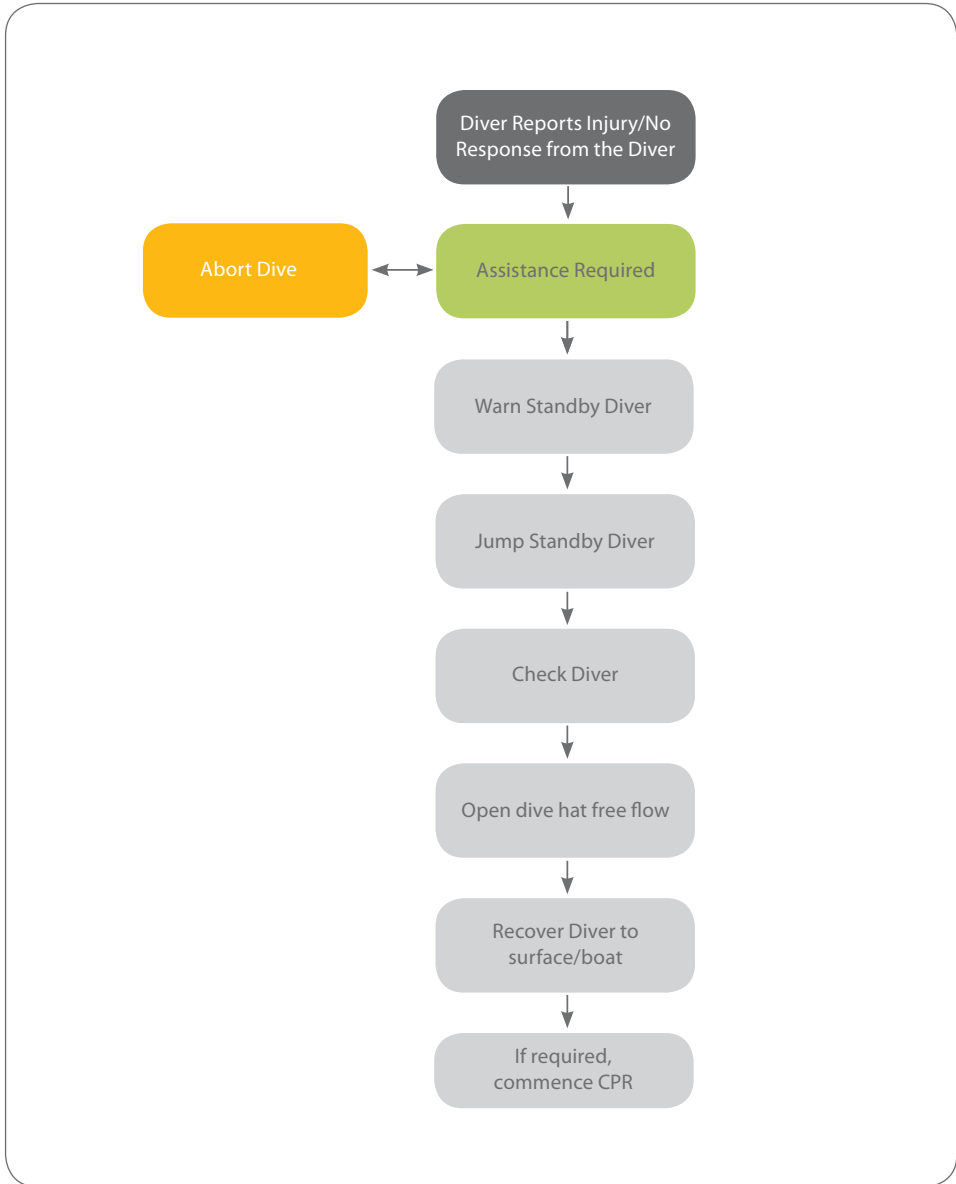
Exposure limitations for surface orientated diving

The following bottom time limitations have been adopted by the occupational diving industry. These bottom time limitations have been adopted to further reduce the incidence of DCI by reducing the diver's exposure to pressure. The use of these exposure limitations is not mandatory, but it is good diving practice.

Maximum Bottom Time Limitation for Surface Decompression and In-water Decompression		
Depth		Bottom Time Limits (Minutes)
Metres	Feet	Surface Decompression and In-water Decompression
0-12	0-40	240
15	50	180
18	60	120
21	70	90
24	80	70
27	90	60
30	100	50
33	110	40
36	120	35
39	130	30
42	140	30
45	150	25
48	160	25
51	170	20

Annex K: Sample Diving Procedures and Emergency Action Plan for Incidents Involving Loss of Life (Potential or Actual) or Severe Injury

There will be a Diving Operations Manual that will outline the procedures of how the diving contractor operates. The content of such an operations manual should be, but not limited be to the following outline:



Annex L: Sample Permit to Work Example

Diving Permit To Work										
Date:			Time:			Permit No.:				
Area Authority:										
Location:				Planned Work Schedule		Start		Date		
						Finish				
Diving Contractor			Name:			Contact (Tel):				
Diving Supervisor In-charge of Worksite			Name(print):			Signature:				
Sea State:		Wind Dir/Spd:		Swell:		Current Dir/Spd:				
Description of Work:										
Description of Diving Equipment/Plant/Tools to be Used:										
Supporting Documents / Permits Attached										
Isolating Mechanical	Y / N	No:	Isolating Electrical	Y / N	No:					
Hot Work Permit	Y / N	No:	Entry Permit	Y / N	No:					
Diver Down boards in place:			Y / N	Equipment Tagged Out/Locked Out:						Y / N
Risk Assessment Completed:				Y / N						
Pre-dive Checks Completed				Y / N						
Toolbox Talk Completed:				Y / N						
Special Precautions Required:				Y / N (if Yes, list)						
Personal Protective Equipment:										
Hard Hat	Safety Footwear		Safety Glasses		Coveralls		Gloves			
Additional PPE	Life Jacket, Safety Harness, Ear Protection, Work Vest, Other (specify)									
Is a First Aider available on site?							Yes	No		
Is a First Aid kit available on site, has it been checked?							Yes	No		
Permit Issue		Applicant		Issuing Authority		Approval Authority				
Date/Time										
Name/Sign										
Revalidation		Applicant		Issuing Authority		Approval Authority				
Date/Time										
Name/Sign										
Permit Cancellation		Applicant		Issuing Authority		Approval Authority				
Date/Time										
Name/Sign										

Annex M: Sample Air Dive Record Sheet – Template

Air Dive Record Sheet (unique sheet number here)					Diving Contractor Logo Here		
NOTE: THIS 'GENERIC' RECORD SHEET TO BE MODIFIED BY THE DIVING CONTRACTOR AS REQUIRED FOR USE							
Date:		Project No.:		Location:			Dive#:
Client:							
Dive Boat (Workboat) Checks Completed:						Black Box #:	
Job Description							
Environmental Conditions							
Diving Team and Personal Equipment							
Dive Supervisor:				Diver Briefing Completed:			Date/Time:
Diver 1:		Bailout:		%		Bar	Hat:
Diver 2:		Bailout:		%		Bar	Hat:
Standby 1:		Bailout:		%		Bar	Hat:
Dive Tender #1:				Dive Tender #2:			
Tender/Boat crew:				Tender/Boat crew:			
Technician #1:				Technician #2:			
Air Supply Record							
PRE-DIVE HP AIR STATUS							
LP Comp:	%	Receiver Press		Line Press		Dive information / activities	
HP # 1:	%	Bottle Press		Line Press			
HP # 2:	%	Bottle Press		Line Press			
HP # 3:	%	Bottle Press		Line Press			
Dive Information							
Dive Details		Diver 1		Diver 2/ Standby Diver			
Left Surface:							
Arrived Bottom:							
Left Bottom:							
Bottom Time:							
Max Depth (meters):							
Table & Schedule:							
In-Water Stops							
Depth	Stop Time	Time Arrived	Time Left	Stop Time	Time Arrived	Time Left	
12msw							
9msw							
6msw							
3msw							
Arrived Surface							
Surface Decompression Required: Y / N				Surface Decompression Worksheet Number:			
Accident / Incident Report: Diver Condition: Post Dive: Fit / Unfit (circle as required)				Dive Supervisors Name (print): Signature: Date:			
Client Rep Name (print):							
Signature: Date:							

Annex N: Sample Air Chamber Decompression Sheet - Template

Air Chamber Decompression Sheet (unique sheet number here)						Diving Contractor Logo Here							
NOTE: THIS 'GENERIC' RECORD SHEET TO BE MODIFIED BY THE DIVING CONTRACTOR AS REQUIRED FOR USE													
Date:				Project No:				Location:					
Client :						Vessel:							
Diver Name:						Dive Number:							
Chamber Operator:						Dive Time (Bottom time):							
Decompression Schedule:													
PRE-DIVE CHAMBER AIR & OXYGEN STATUS													
LP Comp:	%	Receiver Press		Line Press		HP Air:	%	Bottle Press		Line Press			
Chamber Oxygen 1	%	Bottle Press		Line Press		Chamber Oxygen 2	%	Bottle Press		Line Press			
Clock Time at Chamber Depth								Notes, including Chamber Venting Times					
Depth	Elapsed Time		Clock Time		Mix (Air / O2)								
Clock Time Chamber Reached the Surface													
Accident/Incident Report required: (circle as required)						Y / N		Diver's Condition after Chamber Decompression: Well/Unwell (circle as required)					
Diver's Name (print):						Chamber Operator's Name (print):							
Signature:						Signature:							
Date:						Date:							

Annex O: Sample Form for Medical Examination of Divers

The Medical Examination/Assessment of Divers			
Diver's Personal Details			
Surname:			
Forename(s):			
Date of Birth:			Sex: Male / Female
Permanent Address:			
Ethnic Origin:		Nationality	
Examining Doctor's Details			
Name:			
Telephone:			
Signature:			Date:
Doctor's Stamp:			
Type of Medical			
Type of medical:		Preliminary examination	Annual assessment
Date of examination:		Date of expiry of certificate of fitness (if applicable)	
Is the diver medically fit	If 'No', please explain. Record actions taken (specialist reports, discussions with approved doctors, etc.) to dive?		
	Yes		
	Not		
If 'Yes', are there any restrictions?	If 'Yes', please explain.		
	Yes		
	No		
Medical History			
Details of any illness or contact with doctors in last year			
Details of any medication being taken:			
Smoking status:		Alcohol Consumption:	
Allergies:			

Continued on next page

Annex O: Sample Form for Medical Examination of Divers (...continued)

The Medical Examination/Assessment of Divers

Diving History

Details of the diver's work history to set against the medical assessment. To be completed for annual assessment only.

Diving certificate number, qualifications and dates:					
Commencement date of commercial diving:					
Type of diving work undertaken:					
What breathing equipment is used:					
Diving activity in last year:	Number of air dives:		Number of days in saturation:		
Details of any diving abroad:					
Any diving-related medical problems and number of working days lost since last medical:					

All aspects of this medical should be conducted at the preliminary examination and each annual assessment unless specifically stated.

Morphology

Height (m):		Weight (kg)		BMI:	
-------------	--	-------------	--	------	--

Respiratory System

Examination of chest. If 'Abnormal', please give details:

	Normal				
	Abnormal				
	Predicted:		Actual:		
FEV1					
FVC					
FEV1/FVC					

Cardio-Vascular System

Examination of cardio-vascular system, including heart sounds. If 'Abnormal', please give details:

	Normal				
	Abnormal				
BP mmHG:		Resting ECG*:		Post- exercise ECG*:	

*as required

Annex O: Sample Form for Medical Examination of Divers (...continued)

The Medical Examination/Assessment of Divers			
Exercise Testing			
Type of test used:			
Results:			
Central Nervous System			
Examination. If 'abnormal', please give details			
	Normal		
	Abnormal		
Peripheral Nervous System			
Examination. If 'abnormal', please give details			
	Normal		
	Abnormal		
Musculo-Skeletal System			
Examination of chest. If 'abnormal', please give details:			
	Normal		
	Abnormal		
Ears (attach copy of audiogram if performed)			
Examination of ears, including external canal, drums and eustachian tube function. If 'abnormal', please give details:			
	Normal		
	Abnormal		
Audiogram performed:		Yes	No
Vision			
Examination of eyes and fundus. If 'abnormal', please give details:			
	Normal		
	Abnormal		
Dental			
Examination. If 'abnormal', please give details:			
	Normal		
	Abnormal		

Annex O: Sample Form for Medical Examination of Divers (...continued)

The Medical Examination/Assessment of Divers						
Urology						
Genito-urinary examination.						
	Normal					
	Abnormal					
Urinalysis:		Protein		Sugar		Blood
Integument						
Examination of skin. If 'abnormal', please give details:						
	Normal					
	Abnormal					
Radiography						
Chest - PA insp. and exposure films:						
Long bone X-rays*:						
Haematology						
Haemoglobin:		Full blood count:		Sickle test:		

*as required

Annex P: Sample Mariners Sea State Chart- Beaufort Scale

Wind Scale/Speed/Effect Chart					
Wind Force (Beaufort Scale)	Wind Description	Wind Speed (Knots)	Approx. Sea State	Approx. Mean Wave Height (m)	Approx. Max Wave Height (m)
0	Calm	0 to 1	Mirror	0	0
1	Light Air	1 to 3	Ripples	0	0
2	Light Breeze	4 to 6	Small Wavelets	0.1	0.3
3	Gentle Breeze	7 to 10	Large Wavelets	0.4	1
4	Moderate Breeze	11 to 16	Small Waves	1	1.5
5	Fresh Breeze	17 to 21	Moderate Waves	2	2.5
6	Strong Breeze	22 to 27	Large Waves	3	4
7	Near Gale	28 to 33	Sea Heaps Up	4	5.5
8	Gale	34 to 40	Moderately High Waves	5.5	7.5
9	Severe Gale	41 to 47	High Waves	7	10
10	Storm	48 to 55	Very High Waves	9	12.5
11	Violent Storm	56 to 63	Exceptionally High Waves	11	16
12	Hurricane	64+	Sea Completely White	14	+

Annex Q: Sample Recommended Equipment Periodic Test and Examination Schedule

No.	Item	Competent Person	Frequency	Type of test	Test Standard
1.0	Surface compression chambers	Person specialising in such work	2 years	Pressure leak test at maximum rated working pressure, using typical gas or gas mixture.	To a recognised international or national standard. Typically, a leakage rate of up to 1% pressure drop in 24 hours is acceptable.
2.0	Surface compression chambers	Engineer specialising in such work	Once every 5 years or in accordance with design code or standard	Pressure test	To a recognised standard.
3.0	Other hydraulic pressure vessels and associated pipe work, and fittings	Person specialising in such work	2 years	Internal hydraulic pressure test at maximum rated working pressure, or in accordance with the relevant design code or standard.	To a recognised international or national standard.
4.0	Umbilicals: - Surface demand hoses - Divers' umbilicals - Other hoses (pressure retaining parts only)	Person specialising in such work	2 years	<p>Either</p> <ul style="list-style-type: none"> • A pressure leak test, or • An internal hydraulic pressure test. <p>A pressure leak test should be carried out if the item normally carries a gas and the test pressure should be at the maximum rated working pressure of the item using typical gas or gas mixture. An internal hydraulic pressure test should be carried out if the item normally carries a liquid and the test pressure should be in accordance with the relevant design standard</p>	To a recognised international or national standard.
5.0	All items above	Person specialising in such work	6 monthly	Visual examination and function test.	To a recognised international or national standard.

Annex Q: Sample Recommended Equipment Periodic Test and Examination Schedule (...continued)

No.	Item	Competent Person	Frequency	Type of test	Test Standard
6.0	Gauges (Depth gauges, dive computers, pressure gauges)	Person specialising in such work- normally a third party company	6 months	Calibration test and necessary adjustments, including the production of a calibration chart if appropriate. Tests to be carried out over the full range of the gauge using the typical gas, gas mixture or fluid medium that is used in practice.	In accordance with equipment suppliers standard procedures.
7.0	Compressors	Person specialising in such work	2 years	<ul style="list-style-type: none"> An internal pressure test at the maximum rated working pressure (or in accordance with the relevant design code or standard) using any gas stipulated by the competent person with a view to ensuring the integrity of the system An internal pressure leak test at the maximum rated working pressure using a gas or gas mixture stipulated by the competent person A test to determine purity of gases or gas mixture being supplied to the diver(s). 	To a recognised international or national standard.
8.0	Compressors	Engineer specialising in such work	6 months	Compressors are to be tested for the pressure and delivery rates intended, and for purity of the pressurised gas.	To a recognised international or national standard with particular emphasis on the purity of pressurised gas produced.
9.0	Diver's helmets, masks, first stage and second stage regulators	Person specialising in such work	6 months	Visual examination and inspection and test in accordance with manufacturers guidelines.	Manufacturers requirements.

Annex Q: Sample Recommended Equipment Periodic Test and Examination Schedule (...continued)

No.	Item	Competent Person	Frequency	Type of test	Test Standard
10.0	Diver's helmets, masks, first stage and second stage regulators	Person specialising in such work	Annual	Annual examination and inspection and test in accordance with manufacturers guidelines.	Manufacturers requirements.
11.0	Electrical systems	Engineer specialising in such work	6 months	All electrical circuits and equipment must be tested for insulation resistance and correct functioning using suitable instrumentation.	To a recognised international or national standard, but also taking into account relevant specific recommendations in recognised codes or guidance notes.
12.0	Fire extinguishing equipment	Person specialising in such work	6 months or such shorter periods as may be required for proprietary items	For fixed and mobile sprinkler or drench systems, a functional test and examination, as required. For proprietary fire extinguishing and equipment, the test and examination should be stipulated and carried out by an authorised representative of the supplier.	To a recognised international or national standard.
13.0	Portable gas analysing equipment	Person specialising in such work	28 days	The equipment should be tested using standard test kits compatible with the equipment and the possible environmental hazards.	In accordance with equipment suppliers standard procedures.
14.0	Gas cylinders (under water)	Suitably qualified engineer employed by the equipment manufacturer or other firm or person specialising in this type of work	6 monthly 2 years	Internal and external visual examination. Internal hydro pressure test, together with detailed examinations of the cylinder internally and externally and all associated and constituent parts.	To a recognised international or national standard.

Annex Q: Sample Recommended Equipment Periodic Test and Examination Schedule (...continued)

No.	Item	Competent Person	Frequency	Type of test	Test Standard
15.0	Gas cylinders (on surface)	As above	5 years	Internal hydro pressure test together with detailed examinations internally and externally of the cylinder and all associated and constituent parts.	To a recognised international or national standard as determined by the competent person.
16.0	First Aid Kit	Person specialising in such work	6 months or such shorter periods as may be required for proprietary items	Inspection of the equipment that it is in good condition and in-date	WSH First Aid Regulation
17.0	Lifting gear forming part of diving plant and equipment	Engineer specialising in such work	6 months	Functional test at maximum normal working load to ensure that all items are operating correctly. This test to be carried out through the full working range of the equipment, including the operation of brakes. All equipment to be examined after test for possible defects.	To a recognised international or national standard.
18.0	All lifting gear not forming part of the diving plant and equipment	Engineer specialising in such work	6 months	A thorough examination of all items to ensure that they are in good condition and working order. The competent person may require that some items are tested prior to a thorough examination if, in his considered judgment, it is necessary.	To a recognised international or national standard.

Annex R: Sample Template for Incident Investigation Reporting

Initial Incident Report			
Incident Category		Near Miss	
		Incident with Injury and/or Illness	
		Incident with Damaged to Asset, Environment	
		Public Complaint	
Where and When			
Location Of Incident		Date Of Incident	Incident Time
Those Involved			
Client & Representative Name	Diving Contractor	Third Party Involved	
		<input type="checkbox"/>	Yes
		<input type="checkbox"/>	No
If "Yes" give details in the incident description below			
People Injured			
No. Of Injured People	Injured People Name	Employee Of	
What Happened?			
One line summary of the incident			
Full description of the incident <i>(Use extra pages if required)</i>			
Actual and Potential Severity <i>(Please circle the categories involved)</i>			
Severity (Low Medium high)	Hazard Severity		
Actual	Low	Medium	High
Potential	Low	Medium	High
Reported By			
Name	Company & Position	Date	

Annex S: Sample Emergency Contact List Format

Agency Emergency Support Services	
Coast Guard Location: Ph Number:	Fire Service Location: Ph Number:
Ambulance Location: Ph Number:	Navy Location: Ph Number: Mobile Number:
Port Authority Location: Ph Number: Response Time:	Harbour Master Location: Ph Number: Mobile Number:
Diving Emergency Support Checklist	
Emergency Services# Radio Frequency	Port Authority# Radio Frequency
Recompression Chamber Location: Operator Name: Ph Number:	Client Location: Name: Ph Number:
Emergency Transportation Location: Name: Ph Number:	Nearest Hospital Location: Name: Ph Number:
Diving Doctor Location: Name: Ph Number: Mobile Number:	Weather Centre Location: Name: Ph Number:

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Notes