The Diving Medical Advisory Committee

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Saturation Diving Chamber Hygiene

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Supersedes DMAC 26 dated June 1995, and Rev 1 dated 1st Jan 2016which is now withdrawn

Document Summary

This document provides guidelines on hygiene practices for saturation diving to prevent infections, particularly in the closed, humid environments of diving chambers.

- **Infection Risks in Saturation Diving:** The closed environment of saturation diving increases the risk of infections due to enhanced microbial growth, particularly from sources like water supplies, equipment, and food.
- **Microbial Contaminants:** Gram-negative bacteria, especially Pseudomonas aeruginosa, are the primary cause of superficial infections in divers. Legionella can also pose a risk for lung infections.
- **Personal Hygiene Measures:** Divers should maintain high personal hygiene standards, including regular showers, clean clothing, and proper wound care, to minimize infection risks.
- **Chamber Cleaning Protocols:** Regular cleaning and disinfection of the diving chamber are essential with appropriate disinfectants recommended to control microbial growth.
- **Environmental Control:** Maintaining low humidity and ensuring the purity of water supplies are critical for infection prevention in saturation diving environments.
- **Further Measures and Monitoring:** Routine microbial analysis of chamber surfaces and water quality testing should be conducted to ensure effective cleaning and infection control practices.

Version history

Date	Changes	Revision
June 2025	Updated guidance on the management of ear infections Updated guidance on chamber cleaning Updated guidance on swabbing of ears and chamber surfaces Added the importance of a water safety plan Added correct choice of diver headphones	Rev. 2
January 2016		Rev. 1
June 1995		Initial publication

1 Introduction

Infection is the most frequent medical problem encountered during saturation diving. The closed environment, with raised temperature and humidity as well as hyperoxia contribute to enhanced microbial growth. Superficial infections, especially of the external ear canal and of soft tissues following minor wounds, are particularly common. Research has suggested that a significant source of microbial contamination in the chamber environment is the fresh water supply and sea water. Other sources may include equipment, food and materials introduced into the chamber. It is believed that the divers themselves are not normally significant contributors to the introduction of infections or the spreading of Pseudomonas aeruginosa infections. Thus, measures to prevent infections can include control of microbial growth in water supplies and equipment.

This guidance note considers those few microbes of particular relevance to saturation diving (certain bacteria, and, to a lesser extent, some fungi and viruses) and describes measures to prevent/discourage infection by them.

This guidance note will be updated as further relevant research and knowledge concerning microbes becomes available.

2 Microbes and Saturation Diving

2.1 Bacteria

Predominant among the many microbes present in a saturation system environment are Gram-negative bacteria – principally the pseudomonas and the coliform (e.g. proteus, klebsiella and E. coli) groups. The pseudomonas group is a natural inhabitant of fresh and sea water and can thus readily enter a saturation system. The main source of coliforms is faecal excretion, therefore the organisms are an inevitable contaminant of chambers.

Skin and other superficial infections from Gram-negative bacteria are more common in the hyperbaric environment than in normobaric conditions. Notwithstanding the wide range of microbes in the chamber complex, the majority of superficial infections (including that of the external ear canal – otitis externa) in divers are caused by one single species – *Pseudomonas aeruginosa* (formerly known as Pseudomonas pyocyaneus, hence 'pyo'). Furthermore, long term surveillance has demonstrated that only a very few genetic types (genotypes) of P. aeruginosa are responsible for infections.[1]

Legionellae are ubiquitous in freshwater and thrive in man-made water systems operating between 20 °C and 45 °C. The main risk is lung infection (Legionnaires' disease) due to inhalation of mist containing Legionella. A water safety plan compliant with international and local regulations will reduce the risk of infection.[2]

2.2 Fungi

Fungi and their spores are widespread, and, like Gram-negative bacteria, grow well in warm and humid conditions. Some fungi are normally present on human skin, and in saturation conditions these are more likely to cause superficial infections. Fungi can cause a variety of other infections, but there is no specific predisposition to them in the hyperbaric environment.

2.3 Viruses

Viruses, which spread from human to human by a variety of routes, cause several of the most common infectious illnesses. Viruses causing respiratory infection are most frequently transferred by airborne droplets produced by, for example, coughing and sneezing. Droplet spread in the confined chamber community can result in transmission of unwelcome but not serious infection, e.g. the common cold. Thorough and effective cleaning of shared equipment (such as helmets) is an important control measure to minimise the risk of transmission.

The HIV and Hepatitis B viruses are spread by direct contact with the body fluids of an infected individual (principally blood to blood). Though sensible and normal hygiene practices (summarised below) ensure the

risk of infection is no greater in hyperbaric than normobaric conditions, these two viruses receive a mention here as they have necessarily received considerations specific to diving.

Norovirus infections are increasingly seen on vessels. In a tight-closed environment a Norovirus infection can spread very fast and disable the entire dive team – thus if suspected, immediate action is needed.

3 Measures to Safeguard Against Bacterial Infection

Consideration is given to personal hygiene, both general (common to normobaric and hyperbaric conditions) and specific to saturation diving, to prevention of infection of the external ear canal, and to chamber and equipment cleansing routines and environmental control.

3.1 Personal Hygiene Measures

A high standard of personal hygiene is important.

Divers should be free from infection before being committed to saturation. The pre-sat medical examination should identify any cuts / wounds / abrasions. If possible, these should be photographed and advise sought from the Company's Diving Medical Adviser

Regular showers are advisable throughout saturation – at least once daily and after each bell run. The diver should use a neutral or slightly acidic soap to prevent destruction of the protective bacteria on the skin. The ears should be kept dry during showering to reduce the possibility of bacterial growth and soap remnants in the external ear; this can be readily achieved by, for example, occluding the entrance of the canal with clean gauze smeared with Vaseline. After having a shower in sat, advised practice is to dry either using two towels – one for the head and neck and one for the rest of the body – or to at least (if using one towel) start with the head and neck and work down – helping to keep infections away from the head and neck.

Regular changes to clean, non-restrictive and comfortable clothing are suggested to help protect the skin.

Lock-out of used clothes and towelling, etc., should not be delayed after use. Such items should be laundered at a high temperature of a minimum of 85 °C.

Bedding including pillow cases should be changed regularly and also washed at minimum of 85 °C.

Persistently wet or abraded skin and minor wounds and burns are at significantly increased risk of infection. Even minor wounds need regular meticulous cleaning and covering. (The attendant should wear disposable gloves.) Waste associated with cleaning and dressing wounds or burns should be put into plastic bags for immediate lock-out.

Nails should be cut at right angles to fingers and toes. Attempts to cut at ingrowing toe-nails or corns are not advised as this increases the risk of related sores and infections.

If the skin of the beard area is irritated, shaving should be avoided or limited.

Regular visits to the dentist are encouraged to ensure continuing dental health and hygiene. It is recommended that a diver visits a dentist at least once per year along with visits (if required) to a dental hygienist to ensure the removal of any dental plaque. Good brushing of teeth at least twice a day is the cornerstone of avoiding most dental problems, including both tooth and gum infections. Dental tape is a valuable aid.

The sharing of razors, toothbrushes, combs or towels is not advised. There is no need for personalised eating and drinking utensils, though a drink should not be shared from the same cup. Unused food and drink should be locked-out without delay.

With particular reference to blood spillage, but applying also to vomit, diarrhoea, etc., the principles are to clean up thoroughly using disposable gloves and paper cloths and to then treat the wiped surface with washing followed by chamber cleanser (considered below). All related cleaning materials should be carefully handled and collected into a plastic bag for early lock-out.

As far as is possible, divers should retain diving equipment as personal, e.g. undersuit, suit, headliner. It is not practicable to personalise helmets, and all that can be done between dives is a wipe and rinse. The oro-nasal mask and nose block pads are, however, clearly a significant potential source of infection and so should be washed in clean (possibly bottled) water using an appropriate disinfectant and thoroughly rinsed after each use. Neck dams may require to be cleaned in the bell. Particular care should be taken with items which will be in close contact with the diver's skin to ensure that any cleanser (which may irritate the skin) is washed off adequately before re-use. Suits etc. should be cleaned and dried on the surface between dives.

Headsets and music device ear pieces should also be cleaned regularly to reduce bacterial growth and infection risk. Use of Bone conduction headphones should be considered as an alternative to reduce the need to introduce ear buds into the external auditory meatus.

There is no need to go beyond these simple, personal and routine measures unless circumstances require and guidance can be sought on further actions.

3.2 Prevention and Treatment of Infection of the External Ear Canal

Prophylactic eardrops containing acetic acid (Burow's solution, e.g. Domeboro Otic or Ear Calm) have astringent and antibacterial properties and have been used in the saturation environment as they may help certain divers to minimise the chance of external ear canal infection. With the head leaning to one side, and without allowing the nozzle of the dropper bottle to touch anything, 3-4 drops are placed into the external canal of the ear. The drops should be used for a timed minute in each ear twice daily and following each dive/shower. Divers should retain two bottles for personal use, one for each ear and labelled accordingly.

In the event that an external ear infection is diagnosed, prophylactic ear drops are ineffective and should not be used for treatment. In such cases, the Life Support Supervisor and/or Medic will issue treatment, under the guidance of the company diving medical advisor. Note: Treatment drops should not be used as a prophylactic measure.

3.3 Chamber Cleaning and Disinfection

The risk of clinical infection increases with the duration of saturation and, consequently, with the length of time the chamber remains pressurised. Therefore, it is considered good practice to regularly bring the chamber to surface for thorough cleaning and disinfection. Steam cleaning is commonly used and is highly effective.

Before disinfection, all visible dirt and debris (potential inhibitors of effective disinfection) must be physically removed using appropriate detergents or cleaning solutions. This cleaning step is essential to allow the disinfectant to work effectively.

Chamber cleaning is designed to limit microbial growth and reduce the risk of infection, particularly from moisture-associated Gram-negative bacteria such as *Pseudomonas* species. Disinfection using appropriate liquid antimicrobial agents (detailed below) should be carried out methodically from the top of the chamber downward, with excess liquid ultimately drained from the bilges. Fresh cloths or sponges should be used in relays and disposed of appropriately after limited use.

Prior to a saturation dive, the entire chamber—including service locks, toilet rims, bunk brackets, etc.—should be thoroughly cleaned and disinfected. Deck plates must be lifted during this process. All surfaces that will come into direct or indirect contact with the skin (e.g. shower deck, sink, tables, BIBS masks) and personal equipment (e.g. headsets) must be disinfected using an approved chamber cleanser, left in contact for at least 10 minutes, then rinsed and thoroughly dried. Showerheads should be removed, cleaned, disinfected, rinsed after 10 minutes, and dried. After disinfection, the chamber should be well ventilated, and clean bedding and towels provided.

Aerosol application of disinfectants must be avoided. Most disinfectants are respiratory sensitisers, and so aerosol application of them in an enclosed environment like a chamber poses significant health risks to occupants.

During Saturation Dives:

1. Toilet, sink, and shower areas; service locks and their immediate surroundings; and table surfaces should be cleaned and disinfected daily.

2. Chamber walls, bulkheads, BIBS masks, and similar equipment should be cleaned and disinfected twice weekly.

3. Showerheads should be removed and locked out for cleaning and disinfection on the surface twice weekly.

4. Bilges and the areas beneath deck plates should not be disturbed during saturation but drained of any cleaning or disinfectant solution as needed.

5. Shower areas must be drained promptly after use and floors kept dry.

3.3 Chamber Disinfectant Cleaning Solutions

Several agents are in use or recommended. These include amphoteric surface active agents (e.g. Tego 2000) and potassium peroxymonosulfate (e.g. Virkon, Oxone). Various other products may also be suitable including dish-washing liquid solutions. Dichlorophen (Panacide M) is now less used than previously because of its undesirable properties of strong odour and skin irritation. The amphoteric surface active agent products combine good anti-microbial properties with relatively few disadvantages, e.g. they are odourless and less likely to be irritant to the skin.

The prime requirements of the cleaning agents is that they should be very effective against the microbes known to flourish in the chamber environment and be non-toxic to man. Additionally, the solution should be odourless, non-volatile, and be free from irritant and sensitising properties.

All chamber disinfectants should be used at the appropriate dilution, skin contact should be minimised by the use of personal protective equipment, and they should be applied by cloth or sponge to avoid the formation of an airborne aerosol.

During and after all cleaning processes, all associated used materials should be locked out of the chamber quickly.

3.4 Environmental Control

Safeguarding against infection within chambers involves control of humidity (which should be maintained at the dry end of the range of comfort), the use of hot water at no less than 60 °C for cleaning and meticulous conduct of the on-board procedures to ensure the purity of the fresh water supplies. Samples of potable water supplying the saturation system should be tested by a laboratory at regular intervals and sampling of the water supply to the chambers should be included in the Ship's planned maintenance system and Potable Water Plan.

Legionella contamination of fresh water systems on-board vessels may be a relevant parameter for monitoring. This is particularly applicable if the water source is bunkered water from onshore supplies. Legionella is a fresh water bacterium and production of fresh water from salt water by, for example, reverse osmosis or evaporation, can help prevent introduction of Legionella into the onboard fresh water systems. However, once in the system these bacteria are very difficult to get rid of. In common with P. aeruginosa, there are only certain genotypes that will cause illness.

Particular emphasis should be applied to water quality testing on vessels that have been stacked, laid-up or idle for some weeks. The lack of water circulation can increase the likelihood bacterial growth, especially in "dead legs" in the water circuits. Any testing schedule should accommodate the time required to test for legionella (typically a week in a specialised laboratory).

The use of appropriate disposable 'point of use' medical grade water filters (e.g. Pall Medical filters) on the shower and tap supplies inside the chambers can significantly reduce the risk of introducing pathogenic bacteria into the saturation system. The filters have a finite life and will require replacement on a regular

basis. Other relevant preventative measures in the potable water system include the removal of dead legs, proper temperature of cold and hot water, adding chlorine dioxide, or using copper-silver ionisation.

Focus should also be on food safety for the divers in the saturation complex, for example, by the use of a hazard analysis and critical control point (HACCP) management system.

Contamination from other sources (e.g. divers' travel bags) should also be controlled. As a general and primary precaution, divers should not bring travel bags inside the saturation chamber, as they have accumulated diverse and numerous microorganisms and contaminants through airports, vehicles, hotels, etc. One solution is to use a brand-new bag to enter the living quarters of the saturation system. Then, divers should limit the number of pouches, clothing, and personal items they carry inside the chamber, as each item increases the number of potentially contaminated surfaces.

4 Further Measures

Routine swabs from divers ear canals for microbial analysis are not advisable. Instead, swabs should be considered only for divers exhibiting clinical features of otitis externa. They should only be taken when advised by the diving medical advisor. Depending on the worksite location and time constraints, the reliability of swab analysis results may be questionable and could delay and/or mislead both diagnosis and treatment.

Routine swabs from chamber surfaces, both pre-dive and during saturation, analysed on the vessel (if possible) looking at bacterial load guide the effectiveness of cleaning regimes. However, the focus should remain on preventive measures to reduce the risk of bacterial contamination and growth.

When taking swab samples, using the correct swabbing technique is essential. The swab tip at the end of the stick should only touch the sampled area. Nothing, including fingers, should contact the swab stick.

As a general rule, the extent of chamber contamination and the risk of infection increase with the duration of the dive, especially when chamber complexes remain under pressure for extended periods. When such operations are planned, intermittent surfacing of individual chambers for cleaning and drying helps control contamination.

5 References

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