

The Diving Medical Advisory Committee

DMAC, Eighth Floor, 52 Grosvenor Gardens, London SW1W 0AU, UK
Tel: +44 (0) 20 7824 5520 · Fax: +44 (0) 20 7824 5521

www.dmac-diving.org
info@dmac-diving.org

Saturation Diving Chamber Hygiene

DMAC 26 Rev. 1 – January 2016

Supersedes DMAC 26 dated June 1995, which is now withdrawn

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, the long term surveillance has demonstrated that only a very few genetic types (genotypes) of *P. aeruginosa* are responsible for infections.

The presence of *Legionella* bacteria is mainly related to bunkering of water from on-shore; the main risk is lung infection (*Legionnaires'* disease) due to inhalation of mist containing *Legionella*.

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.

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 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.

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 oronasal mask and nose block pads are, however, clearly a significant potential source of infection and so should be washed in clean (possibly bottled) water, and an antibacterial agent such as chlorhexidine (e.g. Hibitane) 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 be also be cleaned regularly to reduce bacterial growth and infection risk.

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 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 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.

3.3 Chamber Cleansing

The risk of clinical infection increases with the duration of saturation and thus the time the chamber remains at pressure – hence good practice is to ensure that chambers are regularly brought to surface for cleaning. Steam cleaning is often used and is effective.

Chamber cleansing is designed to limit microbial growth (particularly the predominant Gram-negative bacteria) and, therefore, to protect against infection.

Cleansing (with liquid anti-microbial – specific agents considered below) is started at the top of the chamber and is continued downwards, with excess cleanser ultimately drained from the bilges. Relays of fresh cloths/sponges should be used on each occasion and discarded carefully and appropriately after limited use.

Before a saturation dive, the entire chamber (including e.g. service locks, rims of toilets, bunk brackets) should be thoroughly cleansed (with the deck plates lifted) and allowed to dry. The parts of the chamber which will be in direct or indirect contact with the skin (e.g. shower-deck, sink, tables and BIBS masks) and other personal equipment, e.g. head-sets, should be disinfected using chamber cleanser, left for a minimum of 10 minutes, then rinsed and dried thoroughly. Shower-heads should be removed, cleansed, rinsed after 10 minutes, and dried. The chamber should be ventilated and clean bedding and towels provided.

Aerosol application of disinfectant agents must not be used. Almost all disinfectants turn out to be respiratory sensitisers so the use of an aerosol in an enclosed chamber can cause problems for the users and is thus unwise.

During saturation dives:

1. The toilet, sink and shower areas, service-locks and their immediate areas, and table surfaces should be cleansed **daily**.
2. Chamber walls and bulkheads and BIBS masks, etc., should be cleansed **twice weekly**.
3. Shower-heads should be removed and locked out for cleansing on the surface **twice weekly**.

Bilges or floor areas beneath deck plates should be drained of cleanser, but should not be actively cleansed or otherwise disturbed during a saturation dive.

Shower areas should be drained quickly after showering and the floor retained dry.

3.4 Chamber Disinfectant Cleansers

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 cleansers 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.

3.5 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 should be tested by a laboratory at regular intervals and sampling of the water supply to the chambers should be included in the planned maintenance system.

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.

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. Other relevant Legionella 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.

4 Further Measures

Routine swabs for microbe analysis from the ear canals of divers are not advisable. Rather, such swabs should be reserved for use in divers with clinical features of otitis externa, such as pain, itch, or discharge. Routine swabs from chamber surfaces both pre-dive and during saturation can be helpful as guides to efficacy of cleansing regimes, but the main focus should be on the preventive measures, i.e. measures to reduce the risk of bacteriological contamination and growth.

When taking swab samples, it is essential to use the correct swabbing technique: the swab bud on the end of the stick should touch only the part to be sampled, and nothing (including fingers) should touch the swab stick.

As a generalisation, the extent of chamber contamination and risk of episodes of infection increase with the duration of the dive, particularly when chamber complexes remain at pressure for long periods. When such operations are planned, intermittent surfacing of individual chambers for cleansing and drying is beneficial in controlling chamber contamination.