THE BRITISH HYPERBARIC ASSOCIATION

FIRE SAFETY GUIDELINES FOR MULTIPLACE HYPERBARIC TREATMENT FACILITIES

OCTOBER 2018

The opinions, conclusions and recommendations contained in this Guideline are those of the authors and are not to be construed as official or necessarily reflecting the views of the British Hyperbaric Association.

This Guideline is intended to be used in conjunction with other BHA publications as listed below:

Guide to Electrical Safety Standards for Hyperbaric Treatment Centres (1996)
The Training & Education of Hyperbaric Unit Personnel (1999)
Health & Safety for Therapeutic Hyperbaric Facilities: A Code of Practice (2000)

Please always check the BHA web site for the latest edition.

Also, published in Europe:

A European Code of Good Practice for Hyperbaric Oxygen Therapy (2004)
This document borrowed heavily from "The BHA Health & Safety for Therapeutic Hyperbaric Facilities: A Code of Practice", but with one very important difference: The term "The Hyperbaric Therapy Provider" (HTP) is unique to the British Hyperbaric Association (BHA) and if there was to be a non-medical accident in a United Kingdom facility then the HTP is likely to be the first person interviewed and not the Medical Director as in Europe.

If clinical hyperbaric facilities were installed after 1998 then other European Norms need to be considered (see Appendix 1 - Bibliography).

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1.0 INTRODUCTION

1.1 Department of Health Guidelines

Where new hyperbaric facilities are being installed as part of a District General Hospital then the guidance issued by the Department of Health under the title of *'Health Technical Memorandum 05-02 Guidance to Support Functional Provisions in Healthcare Premises'* should be used. The facility should be treated as a life risk compartment and provided with the same fire separation and means of escape as an Intensive Care Unit or Operating Department. Guidance for existing hospitals is contained in *'Health Technical Memorandum 05-02; Fire Code Guidance in support of functional provisions (2015 edition)'*. Similarly, the Department providing Hyperbaric Therapy facilities should have the same fire safety provisions as an Operating Theatre Department. There are many European Norms that relate to any new clinical multiplace hyperbaric system, its installation and its firefighting systems. See the bibliography in Appendix 1 of this guideline. The primary purpose of this guideline is to assist existing multiplace treatment facilities to consider what may be needed to improve the safety of an existing facility.

1.2 Primary Legislation for Fire Guidance

The primary legislation for fire guidance is the Regulatory Reform (Fire Safety) Order 2005. This legislation sits above all other legislation in terms of safety in the event of fire.

The legislation requires that suitable and sufficient risk assessments are carried out which is the process of identifying fire hazards and evaluating the risks to people, property, assets and the environment arising from them, considering the adequacy of existing fire precautions, and deciding whether the fire risk is acceptable without further fire precautions.

Areas to examine are:

- Hazards and Risks present
- Means of Escape
- Numbers of persons present (staff, patients, visitors, contractors and subcontractors and anyone else who may be affected)

Control Measures to include:

- Fire Alarms
- Escape Routes
- Emergency Lighting
- Firefighting Equipment
- Training
- Active Measures i.e. sprinklers and forced smoke control systems

Other relevant pieces of legislation or guidance to consider are:

- Health and Safety at Work Act 1974 (HSWA)
- The Management of Health and Safety at Work Regulations 1999, amended 2006;
- Provision and Use of Work Equipment Regulations 1998; (PUWER)

- Personal Protective Equipment Regulations 2002;
- Control of Substances Hazardous to Health regulations 2002 as amended; (COSHH)
- Confined Spaces Regulations 1997;
- The Building Regulations Approved Document B Volume 2 2013; (ADB)
- EN14931:2006 Pressure Vessels for Human Occupancy (PVHO)-Multiplace Pressure Chamber Systems for Hyperbaric Therapy-Performance, Safety Requirements and Testing
- EN16081+A1:2013 Hyperbaric Chambers Specific Requirements for Fire Extinguishing Systems Performance, Installation and Testing
- A European Code of Good Practice for Hyperbaric Oxygen Therapy 2004
- Electrical Safety Standards for Hyperbaric Treatment Centres BHA 1996
- Health & Safety for Therapeutic Hyperbaric Facilities: A Code of Practice BHA 2000

1.3 International Fire Protection Standards, Norms, Regulations or Guidance

Facilities should refer to the latest editions of documents from Europe and /or the USA if building a new hyperbaric system to the relevant European Norms (EN) documents:

- NFPA 99: 2015 Chapter 14 Hyperbaric Facilities (updated every four years)
- EN14931:2006 Pressure Vessels for Human Occupancy (PVHO)-Multiplace Pressure Chamber Systems for Hyperbaric Therapy-Performance, Safety Requirements and Testing
- EN16081+A1:2013 Hyperbaric Chambers Specific Requirements for Fire Extinguishing Systems Performance, Installation and Testing
- A European Code of Good Practice for Hyperbaric Oxygen Therapy: 2004

These NFPA & EN documents are international recognisable codes / standards that deal sufficiently with Fire safety in hyperbaric facilities. The documents approach hyperbaric firefighting from very different viewpoints, but the desired outcome on fighting fire inside a hyperbaric chamber are likely to be similar.

1.4 Building Regulations, British Standards and European Norms

This guidance presumes compliance with other legislation relevant to the Building Regulations which are applicable to all new building work or a material change of use. The building structure should normally be one-hour fire resisting. For new buildings in England and Wales, advice on the standard for fire resistance and compartmentation is contained in the Building Regulations and the Approved Document B (Vol 2) on Fire Safety. In the past, the construction of the chamber was controlled by BS 5500 "Design of unfired pressure vessels", Lloyds Class 1, PVHO, and/or other relevant National codes

and standards: rather than the Building Regulations. Since 1998 when the UK adopted the European Norm - EN14931, all new clinical hyperbaric system installations are now medical devices and guidance and legislation should be obtained from the relevant European Norms (see Appendix 1 – Bibliography / References).

EN14931 and EN 16081 are very specific to the design, construction, performance, safety and testing of the hyperbaric chamber (medical device) and do not cover existing hyperbaric treatment facilities, plant and their premises.

Every effort should be made to reduce all combustible materials to a minimum. This guidance can be used to assess the fire risk and determine suitable precautions. This should be done by a competent person and the assessment recorded.

A competent person is defined as "a person who can identify existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has the authorisation to take prompt corrective measures to eliminate them".

1.5 Aim of Guidance

This guidance cannot take account of all circumstances which may arise in hyperbaric treatments. It should, therefore, be taken as advice for safety to be achieved rather than a set of measures to be rigidly applied in all circumstances. Neither should this guide be used in isolation. Facilities must ensure that valid Risk Assessments are in place; this is the responsibility of the facility and they must not rely solely on the Fire & Rescue Service (F&RS) for guidance or advice.

1.6 Interaction with Other Safety Requirements

It is important when applying this guidance that other factors are considered such as any conflict with other safety requirements, the degree of supervision likely to be available and the knowledge of specialist staff. Emergency Procedures (EPs) should be prepared and where practical tested to ensure validity. Although most facilities with multiplace chambers do not come under Control of Major Accident Hazards (COMAH) regulations, a COMAH type emergency plan may need to be prepared involving consultation with local authorities including Fire, Police, Ambulance Service, NHS Hospital Trust and the Local Council.

1.7 Acronyms & Abbreviations

A list of acronyms and abbreviations is included in Appendix 4.

To assist teams to produce their own Emergency Procedures (EPs) to cover all possible Fire and / or Evacuation scenarios in a multiplace facility, some examples and an index are included in Appendices 2 & 5.

2.0 FIRE PREVENTION

2.1 Oxygen Concentration

Most fire prevention measures centre around the hazards of oxygen enriched fabrics and atmospheres. Atmospheres of 40% oxygen are extremely hazardous at 1 ATA, but multiplace hyperbaric chambers normally operate at a range of less than 23.5 % oxygen. At higher pressures, further precautions are required. Fire as a physical phenomenon is influenced significantly by ambient pressure, the oxygen available in the confined space and the availability of materials to burn. Materials thought to be non-combustible at 1 ATA may burn fiercely and cause a sudden increase in temperature and high concentrations of toxic gases and smoke at increased pressure. If a fire occurs, it must be dealt with quickly, all occupants should be evacuated and those suffering from breathing difficulties, decompression illness and burns cared for.

A means of analysing the oxygen levels in the chamber or chambers must always be available. The primary oxygen analyser should be fitted with audible and visual alarms for both low and high concentrations. In normal practice, the chamber operator should keep a regular log of these readings. If an oxygen analyser is not available, then do not use the system until the oxygen analyser is replaced or repaired except in a severe emergency case of DCI needing to be treated. Constant flushing of the chamber will be required if there is no functioning oxygen analyser. Monoplace chambers are not covered by this guidance, they may be pressurised on 100% oxygen so alternative guidance should be used.

2.2 Oxygen Dumping

Most treatment regimens require the breathing of oxygen by mask or hood tent. Oxygen exhaled into the chamber will quickly increase the oxygen concentration. Even with flushing / venting, it is difficult to maintain the oxygen level below 25%. Although an increase of oxygen from 21 to 25% may not seem too great a change in percentage terms, it is enough to increase the burning rate by more than 25%. The best way to manage this situation safely is to provide an overboard dump system for all the exhaled oxygen.

All chamber exhausts should be labelled and piped outside the building and clearly labelled and protected to prevent damage or intrusion of rain, snow, debris or insects. "No smoking" / "Oxygen exhaust" signs may be required.

Care should be taken that the BIBS dumps do not exhaust into confined areas or low levels where oxygen could accumulate. Exhausting at a high level is best practice

2.3 Recommended Fabrics

Fabrics used in the chamber such as sheets and clothing should be of 100% cotton materials with NO pockets and only used in the chamber. Curtains or

free hanging drapes should not be provided. If blankets are used, they should be preferably 100% cotton and of a standard acceptable in the normal hospital environment (HTM 05-03 Operational Provisions Part C; Textiles and Furnishings) as a minimum standard. Specialist hyperbaric blankets such as Durette are available and may be used where the risk warrants it. All equipment is to be CE marked to meet requirements of the Provision and Use of Work Equipment Regulations (PUWER) 1998. It has been demonstrated that mixed fabrics when exposed to fire in a hyperbaric environment can melt and seal out water from penetrating the material. Clothing used in the chamber should be issued by the hyperbaric facility, specifically approved by the safety director / officer. All fabrics must be clean before use. Washing with non-biological detergents presents a lower fire risk. Any sound deadening material used inside the chamber should have fire retardant properties.

2.4 Flammable Materials

The use of all sprays, hair and body oils should not be permitted for all chamber occupants. Cosmetics, lotions and oils should be removed from the body and hair wherever possible or practicable. Non-alcohol wipes are recommended for use in chambers. A full list of prohibited materials can be found in Appendix 3.

2.5 Paper

The use of paper should be kept to a minimum within the chamber. It is recommended that newspapers are avoided and magazines limited in number. Storage and waste containers should be metal.

2.6 Chamber Equipment

Equipment used inside the chamber should be kept to the minimum necessary for the operation of the chamber. Only equipment approved by the chamber facility safety director / manager should be allowed inside. All equipment to be CE marked to meet the requirements of PUWER 1998 and EN14931. Plastics should be kept to a minimum. Consider alternatives for plastics.

Environmental Control Units (ECU) may be fitted and this equipment may be used to control temperature and humidity inside the chamber. Normally ECUs will be filled with a water glycol mixture so that a comfortable temperature of approximately 22^0C +/- 2^0C can be maintained.

Equipment made of magnesium or magnesium alloys should be prohibited from inside the chamber.

2.7 Removal of Combustibles

During treatment, non-required combustible items should be "locked out" as a standard operating procedure. Magazines and paper should be kept to a minimum.

2.8 Electrical Equipment

All electrical equipment and wiring within chambers should comply with the relevant regulations. The UK diving industry standard for electrical power in a chamber is a maximum of 24 Volts DC. Consideration should be given to the provision of local sensitive circuit breakers on any system. Any switches within the chamber must be intrinsically safe. It is better to keep all electrical switches outside the chamber. NFPA 99 limits allowable power on each circuit inside the chamber to 28 Volts and 0.5 amps, speakers wiring is to be completely enclosed and rated not to exceed 28 V rms and 0.5 amps.

The floor of the chamber should be non-combustible and mechanically secured and electrically bonded. A continuous ground needs to be maintained between all conductive surfaces on the chamber and the control panel. The electrical ground should be checked at least annually. The common ground check between any items small not exceed 1 ohm.

Equipment with batteries will need to be locked out when new batteries are required.

Lithium batteries of not more than 6 volts & 100 mA (button type like those used in small blood glucose monitors) may be allowed inside the chamber after a through Risk Assessment. All batteries of any voltage need to have a Risk Assessment prior to use inside the hyperbaric environment.

All electrical wiring should be protected from physical damage and from coming into contact with flammable materials.

All communications systems shall connect all locks and the chamber operator at the control panel.

2.9 Pipework, Valves & Regulators

All pipework carrying oxygen or oxygen rich gases (over 25% O_2) must be certified as oxygen clean. Oxygen and oxygen-rich gases must be regulated down to less than 15 bar before entering the main treatment room. Control of the high-pressure oxygen / oxygen-rich gases should be by needle valve. The use of quarter turn valves should be avoided in pressures greater than 10 bar although may be used as emergency shut-offs after an appropriate Risk Assessment.

2.10 Lubrication

Any equipment requiring lubrication inside the chamber should be lubricated with a suitable oxygen-compatible lubricant approved for the purpose to which it is put. Mineral oil or grease in an oxygen environment may cause fire or explosion and must be avoided. Items introduced into the system containing mineral based oils or greases may also, under certain conditions, create an explosion when mixed with oxygen. For example, wheel chairs with

greased wheel bearings. A variety of lubricants will be required for the differing applications within the chamber, but steps should be taken to replace combustible variants where possible and / practicable. Christo-lube or Halocarbon Lubricant 281 are good examples of suitable hyperbaric lubricants for items like 'O' ring seals. Talcum powder may also be a suitable door seal lubricant.

2.11 Flammable Gases

Flammable gases must be stored separately to the oxygen and oxidising gases and not in the chamber enclosure. The use of flammable agents inside a hyperbaric facility or in proximity to any air intake must be forbidden. Gas burners, lighters and matches should not be permitted in the chamber area. Cylinders of gas may be permitted inside the chamber provided the container and its contents are approved by the safety director / officer.

2.12 Emergency Procedures

Emergency Procedures (EPs) (for examples see Appendix 2 & 5) best suited to the needs of the building and facility must be established. All personnel should be instructed on these EPs as a form of induction training. Personnel should be trained to safely decompress occupants when all powered equipment has been rendered inoperative. These procedures should be practised at regular intervals. The contingency plans should identify the alternative hyperbaric facility as in paragraph 4.1. These multiplace EPs are not facility-specific and are purposely written to be brief and to the point and where possible with each on one page. The EPs assume the staff are already very familiar with the systems controls.

Breathing Apparatus (BA) may be required for the chamber operator / supervisor, so they can remain to assist with the emergency decompression and evacuation of the chamber occupants from the risk area.

The chamber supervisor is best placed to make operational decisions for continuation of the therapy and control of the systems throughout the incident; deciding how best to control the therapy should be done through a process of Dynamic Risk Assessment. Consider inviting in the local Fire & Rescue Service (F&RS) to see the hyperbaric facility and explain to them the need for a chamber supervisor to remain at the chamber control panel until the chamber is safely back at 1 ATA / surface and the patients can be safely evacuated from the building. Also refer to the other BHA documents listed in the Bibliography in Appendix 1.

2.13 Contingency Planning

A contingency plan must be developed by either the Hyperbaric Therapy Provider (HTP) or the safety director / officer that clearly defines the responsibilities and activities of all personnel in the event of an emergency. This should confirm that the chamber control is the emergency co-ordinators' location and should specifically identify action plans to be implemented as the situation develops. This plan should be developed as part of an overall

strategy. If the hyperbaric facility forms part of a larger hospital or clinical complex, it should be discussed and lodged with the local F&RS.

2.14 Cleaning

It is essential that all areas of the hyperbaric chamber and the associated plant are kept free of grease, lint, dirt and dust. A regular cleaning programme must be introduced and maintained. Those responsible for cleaning must be given the appropriate induction training. Cleaning materials used inside the chamber or on equipment to be taken inside the chamber must be approved by the chamber facility safety director / officer. Cleaning agents must have no odour and be suitable for use inside the hyperbaric environment. Facilities should seek advice from others or do their own risk assessments on what cleaning chemicals are safe to use inside the chamber. Some examples that are used commonly by some UK hyperbaric facilities include Safe 4 (http://www.safe4disinfectant.com/) and Trigene/Distel (http://www.tristel.com/tristel-products/distel-high-level-medical-surface-disinfectant).

If there is a bilge, easy access needs to be provided for regular cleaning.

2.15 Number of Chamber Occupants & Gas Supplies

The number of occupants in the chamber should be kept to the minimum necessary to carry out the procedure safely with due allowance for the training of personnel. There should always be a suitable alternative Built in Breathing Systems (BIBS) available inside the chamber for all occupants. The gas supply to the BIBS should be independent of the primary chamber supply and sufficient to supply all BIBS simultaneously. All BIBS should be capable of being supplied with air or oxygen and switchable from the chamber control panel.

A back up reserve oxygen supply of 15 minutes' duration should be available for all occupants of all chambers. This reserve oxygen supply will be more than enough to safely decompress occupants for all likely emergencies.

Minimum ventilation rates of 0.085 m^3/ min of air per chamber occupant should be available.

Compressor intakes should be located away from chamber, vehicle, building and generator exhausts.

Air compressors may be oil lubricated provided they have suitable filtration to provide quality breathing air that is checked for quality at least once every six months.

All pipework and gas outlets should be labelled with contents and direction of flow. Pipes should be frequently labelled for ease of quick identification.

Shut off valves accessible to chamber staff should be provided at the point where the piping enters the chamber room.

A master panel and shut off valve displaying the primary oxygen supply should be located within the chamber room and within easy access of the chamber control panel. This master panel may be fitted with alarms to allow for visual and audible monitoring.

2.16 Smoking

As a consequence of the Health Act 2006, Smoking Legislation came into effect in 2007, smoking is not permitted in buildings including any hyperbaric facility. Because of the high hazard nature of such installations, it is recommended that smoking is completely prohibited on and around sites, making due allowance for areas where O_2 is stored and or exhausted / dumped to the atmosphere.

2.17 Prohibited Items and Materials

Appendix 3 lists items and materials prohibited in the multiplace chamber where the maximum oxygen concentration is 23.5%. This list is NOT to be used for a 100% oxygen filled Monoplace chamber.

3.0 CHAMBER CATEGORY SYSTEM

The following clinical chamber category system was introduced into the UK in 1994 by: A Code of Good Working Practice for the Operation and Staffing of Hyperbaric Chambers for Therapeutic Purposes. Published by the Faculty of Occupational Medicine of the Royal College of Physicians.

Categories 1, 2 & 3 should be large enough to accommodate at least two people comfortably with good safe access.

The below table is only a summary of the full criteria required.

Category 1	Comprehensive multiplace hyperbaric facilities capable of supporting ICU patients who are critically ill who may require Advanced Life Support (ALS).
Category 2	Multiplace hyperbaric facility capable of receiving elective or emergency referrals from an accepted list of suitable hyperbaric conditions, but excluding critically ill at the time of referral or those likely to become so & unlikely to require ALS.
Category 3	Multiplace hyperbaric facilities with some of the capabilities of Category 1 & 2 sited specifically for the treatment of Decompression Illness (DCI) cases.
Category 4	Monoplace chambers where access during treatment is not required.

Category 4 chambers are not covered by this Fire Guideline.

4.0 COMMUNICATION AND ALARM SYSTEMS

4.1 Fire Alarm System and Detectors

The Department or facility should have an alarm system capable of detecting smoke or fire and to raise the alarm and signal the pre-arranged evacuation. It will, therefore, have to be designed to the standard of BS5839: Part 1: 2013, 'Fire detection and alarm systems in buildings' with further pertinent advice in Health Technical Memorandum HTM05-03 Operational Provisions Part B; Fire Detection and Alarm Systems.

Guidance is no substitute for adequate risk assessments and discussion of what is to be expected by way of alerting staff and assisting in the rapid location of the fire source, any fire containment measures or extinguishment of the fire. The type of warning signal may require discussion and the importance of the chamber control as the co-ordinator of any emergency

activity must be recognised. The alarms should, therefore, cover all areas including plant and circulation spaces, but the signal to the chamber must be routed via the chamber control console / panel. It is advisable for some form of visual signal to be given at the chamber control when there is a fire condition. Noise from alarms at the chamber control console should not continue to make chamber communications difficult. The ability to be able to silence the alarm sounder only immediately next to the chamber control panel after its initial sounding, leaving only a flashing light next to the control panel should be considered. There should be a call point / break glass at or near the chamber control panel.

There are many types of fire alarm systems each suited to different building types and applications. For hyperbaric facilities in hospitals a type L1 is the only acceptable standard. A type L2 system may be possible in other healthcare premises.

- A category L1 fire alarm system is designed for the protection of life and which has automatic detectors installed throughout all areas of the building (including roof spaces and voids) with the aim of providing the earliest possible warning.
- A category L2 fire alarm system is designed for the protection of life and has automatic detectors installed in escape routes, rooms adjoining escape routes and high hazard rooms.

4.2 Testing and Servicing of Alarms

A weekly test of the fire alarm system should be carried out, which should include using different call points each week. The recommended period between successive inspection and servicing visits should not exceed six months by a certified and registered service engineer. The servicing of fire alarms is covered in more detail in BS5839.

5.0 ESCAPE

5.1 Arrangements for Escape

To ensure that means of escape remains effective, emergency lighting should be installed in accordance with BS 5266: part 1: 2016. Arrangements for escape / evacuation in a hyperbaric treatment facility will depend on the fire evacuation procedures to be adopted. Most staff and visitors will leave on the fire evacuation signal; this may not be immediately practicable or possible for those undergoing treatment and those at the chamber control panel. It may also be wise to have a fire hose reel next to the chamber entrance / exit to assist in firefighting during the emergency decompression and subsequent evacuation of the chamber occupants. In recent years, there has been a move to remove fire hoses from hospitals, but in the case where immediate evacuation cannot be achieved until the chamber is safety decompressed it may be of great assistance to the supervisor left behind. The supervisor left in charge of safely evacuating the chamber occupants may also need to have immediate access to Breathing Apparatus (BA).

The treatment of non-diving related patients should be aborted immediately an emergency is confirmed. These persons should be evacuated as quickly as possible. Decompression must follow the appropriate EPs depending on patient type and treatment duration at the time.

It may be possible to consider moving hyperbaric patients and their attendants to a pre-determined place of safety; in some situations, this may mean having emergency arrangements to transfer them to an alternative chamber within an appropriate time scale. The alternative chamber should be in a separate building or location. In a large compartmented building, it may be acceptable for the facility to be provided in a separate fire compartment with independent engineering systems.

It may in some cases be worth considering installing smoke / fume extraction equipment to only the chamber room. However, this will need to be discussed with competent persons as it may also affect the overall fire rating of the chamber room. If smoke and fumes can be forcibly extracted from the chamber room until the chamber occupants are safely evacuated it may be a huge benefit. Generally, this solution may be difficult to gain approval to install as normally doors and windows are shut to reduce the air flow to the fire and help slow down the spread into adjacent rooms. The F&RS normally will insist on immediate evacuation of everyone from the building, but once it is established that immediate evacuation may not be possible it might be possible to consider better solutions than normally accepted.

5.2 Breathing Apparatus (BA)

If evacuation to a safe place outside the building is to take longer than three (3) minutes (for chamber occupants) or where stabilisation of systems with delayed decompression / surfacing is to take place, Breathing Apparatus may need be provided and the users (Supervisor and / or Operator), as well as other persons who may be required to assist in the risk area, will need to be trained in its use. This training should include exposure to smoke, heat and darkness. These persons should also all have received training in the use of hand-held firefighting equipment and, where the facility risk assessment dictates, the use of hose lines / reels. All persons who are required to assist with the evacuation of patients from the building should receive training in the use of hand-held Fire Fighting Equipment (FFE). Consideration may need to be given to the provision of additional Breathing Apparatus (BA) for other staff assigned to chamber evacuation or life support with the appropriate training. Smoke hoods may also be considered beneficial or as an alternative to BAs to also allow the chamber occupants to evacuate from the chamber once at surface / 1ATA to a safe place outside the building. BA equipment will need a Programmed Maintenance Schedule (PMS). It may be possible to only require one BA set or even an alternative solution after a facility has conducted its own Risk Assessment.

5.3 Emergency Procedures for fire and evacuation

Some examples of fire and evacuation procedures are given in Appendix 2. These EPs are intended as examples and facilities should develop their own EPs. Bullet point short brief (one page) EPs may be better than long documents which may be seldom read. Additional Technical and Medical EPs will also need to be developed and a suggested list of these is included in Appendix 5.

Clinical chambers should be capable to decompress from 3 ATA (20 MSW) to surface / ambient within six (6) minutes.

Training and chamber evacuation drills should be practiced at least annually and records kept showing the time needed to evacuate from the building when the chamber is at a normal therapy pressure with full occupancy.

6.0 EXTINGUISHING FIRES

6.1 Fixed Sprinkler Systems

Where new hyperbaric facilities are built, a fixed sprinkler system should be installed in the building to reduce the spread of fire. Because of delayed evacuation times sprinkler systems may assist in reducing risks whilst surfacing the chamber or maintaining safety where chambers cannot be easily surfaced / decompressed because of the occupant's decompression requirements.

6.2 Fire Fighting Equipment (FFE) in Chambers

A form of first aid fire fighting must be provided in all locks of a chamber. This as a minimum may be an approved specialised water extinguisher or Hand Held Hose (HHH). supplied from a pressurised water receiver with sufficient pressure to function at the maximum working pressure of the chamber. NFPA 99 suggest approximately 3.5 bar over the maximum working pressure (WP) of the chamber. Hyperbaric Firefighting suppression systems should be designed to operate for at least one minute in all locks simultaneously. Ideally the chamber suppression system and the HHH system should be independent of each other. There should be audible and visual alarms in the event the chamber fire suppression system is activated.

Experience has shown that fire blankets and /or portable carbon dioxide (CO_2) extinguishers can be dangerous in controlling fires in hyperbaric oxygen-enriched atmospheres.

On no account should a standard water, water foam, CO_2, or dry powder extinguisher be present inside the pressure chamber as some types are toxic in confined spaces. Hyperbaric-approved modified pressure foam or water units have been designed to operate at pressures incorporating a pressure relief device, and containing non-toxic foam or just water. The propellant gas must be compatible with the breathing mixture.

If pneumatic control valves are used to control the fire suppression, BIBS supply or emergency decompression valves there must be a means to operate the valves manually should the pneumatic supply fail.

In accordance with the fire risk assessment, a fixed fire suppression system, producing water deluge, spray or fog or a combination of these within the chamber, should be provided. This should be the minimum acceptable standard. The activation of the fire suppression system should be possible from the control panel and from within the chamber. The system may be automatic, but must also have a manual override at the control panel.

All new (built & installed after 1998) multiplace chambers are covered by EN14931 and EN 16081. The system may include automatic detection within the chamber and subsequent automatic operation, but with provision for a manual over-ride in case of electronic failure.

6.3 Hand Held Hoses (HHH) and Pressurised Water Receivers

The use of 12 mm hand held hoses (HHH) is acceptable. However, fire hoses should be supplied from a pressurised water receiver preferably independent from the chamber suppression system which will assure a 3.5 bar minimum water pressure above the maximum hyperbaric chamber working pressure. Fire hoses should be fitted with quick action valves and provide a solid water jet at any chamber pressure. Fire hoses may be required at both ends of each treatment compartment, but only long enough to reach all areas of the chamber from either end. Hoses should not be over long to become kinked or obstructed. HHH should be capable of each providing 18 litres per minute when two in any lock are used simultaneously for a minimum period of four (4) minutes. All locks should have at least one HHH or suitable fire extinguisher. All HHHs should be tested during the daily chamber checks. All receiver Pressure Relief Valves (PRVs) should be tested in accordance with the facility Preventive Maintenance Schedule (PMS), or the relevant regulations.

6.4 Alternative Water Supplies

A system which can provide an adequate supply of water at the necessary pressure and volume may be acceptable. However, this system must operate regardless of a primary electrical power failure or one pump failure. There must be adequate redundancy to ensure that the system works regardless of power failures or single pump failures. This system would eliminate the need for a pressurised water receiver. Fire Fighting Equipment pipework that may be subjected to any fire should be either copper, tungum alloy or stainless steel. Plastic pipes should not be used within any part of FFE except perhaps the final hand-held hose (HHH).

6.5 Fixed Extinguishing Systems - deluge, spray and fog

For new installations (after 1998), a fixed extinguishing system should be installed within all clinical chambers. It shall be capable of manual activation.

When operated the system activation should occur within one second. EN14931 and EN 16081 lay down the exact specifications for all new systems.

The duration of fire suppression of the fixed system in chambers may be governed by the capacity of the chamber and its drainage system. There shall be sufficient water available to maintain an adequate flow for one-minute duration. Extinguisher controls should be located both inside the chamber and outside on or next to the chamber control panel.

Since inadvertent discharge of water can disrupt operation of the facility, proper precautions to prevent such an occurrence should be observed.

The duration of application is governed by the type of system. The quantity of water discharged should provide the necessary concentration or saturation throughout the chamber for complete extinguishment. NFPA 99 only states minimum water volumes (Average 81.5 L /min m^2) based on a 'calculated' floor area for each lock (not actual), while the European Norms ask for multiply independent testing and verification. 'Calculated' floor areas (not actual) are obtained by drawing a line though the diameter of the chamber 25% up from the bottom and multiplying by the lock length. Any fire suppression system should deliver water within three (3) seconds of activation of any suppression control valve / button.

Sufficient deluge, spray or fog nozzles may be installed to provide reasonably uniform and adequate coverage to spray both horizontally and vertically. The NPFA99, EN14931 and EN 16081 documents cover this in more detail.

Experience has shown that when water is discharged through conventional sprinkler heads into a hyperbaric atmosphere the spray angle is reduced greatly because of the increased density of the atmosphere even though the water pressure differential is maintained above atmospheric pressure. Therefore, it may be necessary to compensate by increasing the number of water heads or having special hyperbaric nozzles/heads. The system design should be such that, prior to activation of the water firefighting system, interior chamber power may need to be deactivated first.

A bypass circuit may be permitted for testing the water firefighting system. If installed, the bypass circuit should be so designed as to not remain in the test mode. The design of the system should allow for frequent movement of water to avoid any stagnation within the water receivers. The system should be tested as a minimum once every six months and the test records maintained.

6.6 Local Fire & Rescue Service (F&RS)

Local fire-fighters should familiarise themselves with the risks present in hyperbaric chambers; in particular, the risks from pressurised components, high partial pressures of oxygen and the possible delay in evacuating patients. The HTP should explain to the F&RS the need for a chamber

supervisor to remain at the chamber control panel until the chamber is safely back at 1 ATA / surface and the patients can be safely evacuated from the building.

The testing of hyperbaric firefighting systems is recommended every six months. These tests should not be based on using air pressure; experience has shown that only the use of water in tests can provide confirmation of the correct proper activation. Hand Held Hoses (HHH) should be tested briefly during daily routine chamber checks.

Appendix 1

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Appendix 2 - Emergency Procedures & Examples for - Fire &/or Evacuation

The purpose of providing a standard set of Emergency Procedures (EPs) is to ensure everyone in the hyperbaric team understands how to best handle each foreseeable emergency. Unnecessary subtitles, paragraphs, or words explaining the background, purpose or guidelines are not wanted. The title itself, followed by numbered bullet points, should explain everything necessary in the minimum number of words for the EP to be performed by any competent team member.

This is a perfect example of the KISS principle (Keep it Simple, Stupid) and a case of "less is more". There should be no duplication of any kind.

Three sub sections may make it easier for you to find the appropriate EP.

All EPs are numbered and have a title and each sub section has a space for new EPs to be introduced later.

These sections maybe:

1. Fire & /or Evacuation
2. Technical
3. Medical

In this appendix only Section 1 Fire & /or Evacuation (1-7) above is included. There are a further 18 possible titles listed for Section 1. See Appendix 5 for lists of possible Technical and Medical EP titles. Use these EPs or create your own unique EPs as this set is designed to work on ALL Multiplace chambers (single or twin lock).

Where possible all EPs are only one page and even then, if facilities were to produce crash cards, only the essential words /points would need to be listed. All EPs are in metric and include abbreviations, which should be well understood by the competent trained hyperbaric team members. These abbreviations include but are not limited to: ALS, O_2, CO, CO_2, DCI, CAGE, UPS, LOX, BIBS, BGL, ATA, MSW, kPa, BLS, CNS, USN, HBOT, IV, ConVENTID, HP, SOP and LP. See Acronyms and Abbreviations in Appendix 4.

Experience has shown that each facility should produce their own unique EPs for their sites; it has, however, been repeatedly shown that many sites do not have good EPs, or know where they are, or even regularly practice them. Also consider that English may not be the reader's first language so for example "DCI watch" may be better written as "DCI observation" for those whose English is a second language.

If the hyperbaric team members do not know the location of certain pieces of equipment, certain valves, emergency telephone numbers or extensions numbers then they need to be re-trained or replaced. As an example, when driving a car, the driver needs to be familiar with their own systems and which side of the steering wheel the indicator arm is on, where the lights turn on or where the windscreen wipers turn on. Regularly practice of all the facility EPs as a team should be encouraged.

Emergency Procedures (EPs) Section 1

Fire & /or Evacuation

1.0 Accidental activation of the chamber fire suppression system (multiplace)

2.0 Fire inside the chamber (multiplace)

3.0 Fire inside the chamber room (multiplace)

4.0 Fire in the building but outside the chamber room (multiplace)

5.0 Action sheet for discovery of fire or smoke

6.0 Action sheet for a person receiving a telephone call of a terrorist threat

7.0 Checklist for person taking the phone threat

8.0 Action sheet for a bomb threat / arson for the person in charge

9.0 Action sheet for hold up or assault - Check list

10.0 Action sheet for hold up or assault - All staff

11.0 Action sheet for hold up or assault - Emergency Controller

12.0 Action sheet for evacuation of the wound care room

13.0 Action sheet for evacuation - Emergency Controller

14.0 Action sheet for evacuation reception

15.0 Evacuation Kit

16.0 Action sheet for evacuation of the multiplace chamber room

17.0 Evacuation of chamber occupants on a motor vessel mounted (multiplace) chamber

18.0 Evacuation of the chamber occupants in a clinic or hospital (multiplace)

19.0 Evacuation exercise observation - checklist

20.0 Earthquake (multiplace)

21.0 Fire affecting chamber supplies

22.0 Emergency entry of outside assistants to the facility

23.0 Emergency entry of outside assistants to the chamber

24.0 Requesting help to the facility

25.0 Chamber decompression by the inside attendant

EP 1.0 Accidental Activation of the Chamber Fire Suppression System (Multiplace)

1.1. Once the deluge system is activated all BIBS should be switched to Medical Air (either manually or automatically).

1.2. The chamber may start decompressing at the maximum rate if the system is automated.

1.3. Once you are 100% sure the activation was accidental, reassure all occupants there has not been a fire, it is an accident and tell them not to hold their breath.

1.4. On a manual system begin a normal ascent.

1.5. Locate where the deluge was activated from and try to reset the fire emergency button or handle that was mistakenly pressed / opened.

1.6. Organise towels and dry clothes for the occupants.

1.7. Open the bilge drain(s) valve to reduce the depth of the water inside the chamber and increase the ascent rate.

1.8. Make sure all other team members and the building supervisor know the fire suppression activation was an accident.

1.9. Debrief patients, relatives and staff involved in the incident. The Director of Nursing, the duty doctor or the Medical Director should undertake the debrief.

1.10. Monitor all for signs and symptoms of DCI and barotraumas and check for any omitted decompression for all occupants

1.11. Be ready to arrange for recompression of any person(s) with signs and symptoms of DCI.

1.12. No treatments are allowed until chamber is clean and dry.

1.13. All components inside chamber need to be dried and tested.

1.14. The deluge water receiver will need to be refilled and pressurised before any further treatments can commence.

1.15. The chamber should not be used again until the technical staff have given their approval.

1.16. Complete an incident form, including all the timing of the events.

1.17. Reschedule treatments.

EP 2.0 - Fire Inside the Chamber (Multiplace)

As quickly as possible carry out the following. Do not hesitate. If you made a mistake the only side effect is that someone gets a little wet & cold.

2.1 Activate the fire deluge either at the control panel or from inside the chamber.

If no deluge is fitted, then tell the attendant to use the chamber fire extinguisher or Hand-Held Hose (HHH)

2.2 Shout "Fire, Fire, Fire".

2.3 When the fire suppression is activated the chamber may decompress automatically. If not, start a controlled emergency decompression following your own facilities guidelines.

2.4 Attendant may also use the Hand-Held Hose (HHH).

2.5 Switch all BIBS to Air if not done automatically. Try and keep all chamber occupants, including the attendant, on BIBS to reduce the smoke inhalation.

2.6 **RAISE THE ALARM BY OPERATING THE NEAREST FIRE ALARM BREAK GLASS CALL POINT**

2.7 Switch off any ECU fans.

2.8 Any other staff member needs to call the emergency services and ask for the F&RS immediately on hearing the fire alarm. This can be done by telephone. Dial '999' or 112.

2.9 Gather as many wheelchairs as needed for evacuation.

2.10 All non-essential staff are to leave the facility and follow local evacuation procedures. Turn off the O_2 supplies going into the chamber room as close as practical to the external source.

2.11 Chamber operator to put on the Breathing Apparatus (BA) or a smoke hood and be ready to evacuate the chamber occupants to a pre-agreed safe area(s).

2.12 Ensure that blankets / towels and a fire extinguisher are available.

2.13 Evacuate the chamber occupants as soon as the chamber surfaces.

2.14 Ensure a DCI observation is placed on all chamber occupants.

2.15 Be ready to arrange for recompression of any person with signs and symptoms of DCI.

2.16 Administer necessary medical attention and identify a new attendant who has not been under pressure in the last 18 hours.

2.17 Complete an incident form, including the timing of the events, debrief the patients and notify the necessary reporting authorities both verbally and with a follow up written record of the event within 24 hours.

EP 3.0 – Fire Inside the Chamber Room (Multiplace)

3.1 Shout **"Fire, Fire, Fire"**.

3.2 **RAISE THE ALARM BY OPERATING THE NEAREST FIRE ALARM BREAK GLASS CALL POINT**

3.3 Chamber operator to put on the breathing apparatus (BA) or the smoke hood.

3.4 Outside attendant to immediately evacuate the room of all occupants (except the one chamber Supervisor / operator).

3.5 If safe to do, immediately use the fire extinguisher / fire hose to attempt to put out the fire.

3.6 Close all room doors in the immediate vicinity.

3.7 Telephone the emergency services by dialling 999 or 112 and give the F&RS the full site address.

3.8 Inform the chamber occupants that a controlled emergency decompression is about to commence and all patients to remain on BIBS O_2.

3.9 Quickly consider any occupants' decompression obligations and start a controlled emergency decompression. If the chamber cannot be decompressed safely to surface then decompress to half the present pressure or 9 MSW with all occupants to remain on BIBS oxygen.

3.10 All non-essential staff, patients and visitors are to leave the premises and evacuate to the pre-arranged assembly area(s).

3.11 Once the chamber is on surface evacuate the remaining chamber patients and staff through the safest exit and report to the pre-arranged "Emergency Assembly Area(s)"

3.12 Gather necessary medical equipment and the patient / staff register and move to the Assembly Area(s).

3.13 If safe to do so, turn off the O_2 supplies going into the facility as close as possible to the external source.

3.14 Carry out a roll call to ensure no one is missing.

3.15 Complete an incident form, including all the timing of the events and notify necessary reporting authorities both verbally and with a follow up written response within 24 hours of the event taking place.

EP 4.0 - Fire in the Building, but outside the Chamber Room (Multiplace)

As quickly as possible carry out the following, do not hesitate.

4.1 On seeing the fire shout "**Fire, Fire, Fire**".

4.2 Identify if the emergency/alarm is relevant. The chamber operator must remain with the chamber if they have occupants.

4.3 Remove all staff and members of the public from the immediate vicinity of the fire.

4.4 **RAISE THE ALARM BY OPERATING THE NEAREST FIRE ALARM BREAK GLASS CALL POINT**

4.5 Call for immediate assistance. Staff member to telephone the emergency services by dialling 999 or 112 and give the F&RS the full site address.

4.6 If the FIRE is near and there is a risk to the chamber, commence a controlled emergency decompression.

4.7 Inform occupants of the emergency decompression. All occupants to remain on O_2 supplied BIBS.

4.8 Gather up as many wheelchairs as required.

4.9 Evacuate all non-essential people and follow local evacuation procedures.

4.10 Once the chamber is on surface evacuate all remaining patients and staff through the safest exit and report to the pre-arranged "Emergency Assembly Area(s)".

4.11 Close doors to all rooms to isolate the fire.

4.12 Turn off the O_2 supplies going into to the facility as close as practical to the external source.

4.13 Establish DCI observation for all chamber occupants.

4.14 Be ready / prepare for recompression of any of the occupants with a new attendant.

4.15 Complete an incident form, including all the timing of the events and notify the necessary reporting authorities both verbally and with a follow up written response within 24 hours of the event taking place.

EP 5.0 - Action Sheet: Discovery of Fire or Smoke

Subsequent Action to:

EP02 - Fire inside the chamber.

a) EP03 - Fire in chamber room.

b) EP04 - Fire in the building, but outside the chamber room.

After a fire in the facility, ensure the following are carried out:

5.1 Notify the following staff:

- The facility Medical Director (Who will notify the necessary authority and arrange reporting as required).
- The Facility Director of Nursing
- The Safety Director / Officer
- The HTP / CEO

5.2 Complete any Injury / Incident Reporting and Investigation forms as required by company policy.

5.3 If the chamber was involved in the critical incident, it may need to be taken out of service immediately and all similar chambers may need to undergo a technical inspection by the manufacturer or a competent team. If there is any doubt about any part of the pressure system, then do not use it again until it is declared fit for use by the facility safety officer / director.

EP 6.0 - Action Sheet for a Person Receiving a Telephone Terrorist Threat

6.1 Listen carefully to what the person is saying & take notes.

6.2 If possible, alert other staff that you have a person making threats on the telephone and someone else contact the emergency services on another telephone line by dialling 999 or 112.

6.3 DO NOT hang-up after the call.

6.4 As soon as call has ended, report details to the emergency services.

6.5 Report the threat to a senior person in your area.

6.6 Complete the terrorist threat checklist EP 7.0 on the next page below:

EP 7.0 - Check list for person taking the phone threat

REMEMBER TO KEEP CALM

Who received the call

Name: Telephone No:
Date of call: Time of call:

Record exact words of threat

General questions to ask

What is it? Where did you put it? What does it look like?
When did you put it there? Did you put it there? Why did you put it there?

Bomb threat questions

When is the bomb going to explode? *OR* When will the substance be released?
How will the bomb explode? *OR* How will the substance be released?
What type of bomb is it? What is in the bomb? What will make the bomb explode?

Chemical / biological threat questions

What kind of substance is it? How much of the substance is there?
How will the substance be released?
Is the substance a liquid powder or gas?

Other questions

What is your name?
Where are you?
What is your address?

Callers voice

Accent (specify) Any impediment? (specify)
Voice (loud, soft etc.) Speech (fast, slow, etc.)
Diction (clear, muffled) Manner (calm, emotional, etc.)
Did you recognise the caller? If so who do you think it was?
Was the caller familiar with the area?

Threat language

Well spoken? Incoherent? Irrational?
Taped? Message read by caller? Abusive?
Other?

Background noises

Street noises? House noise? Aircraft? Voices? Music? Machinery? Other?
Local call? STD? Mobile?

Other

Sex of caller? Estimate age?

Call taken

Duration of call? Number called?

Action (obtain details form supervisor)

Report call immediately to? Phone number?

DO NOT HANG UP **DO NOT HANG UP** **DO NOT HANG UP**

Appendix 3 - Items and Materials Prohibited in the Chamber

General

Listing

- Adhesives (F).
- Aerosols (D, E, F).
- Aftershave and cosmetics (D, E F).
- Alcohol (D, F, P).
- Batteries with unprotected leads (F).
- Lithium batteries over 6 volts and/or 100 mAmp (F)
- Chemical cleaners, e.g. trichloroethylene, 'Freon', etc. (D, P).
- Cigarettes, cigars, tobacco of all kinds (F, M).
- Cleansing powder (C, F, P).
- Computers inc. Laptops, smart phones and tablets (E, F).
- Electronic cigarettes (E, F)
- Electrical equipment including tape recorders, radios. etc. (F).
- Explosives including TNT spray. (F)
- Glass thermometers including batteries containing mercury. (C, D, P)
- Ink pens (M).
- Lighters or Matches (F).
- Magazines (Only on the approval of chamber operator) (F)
- Mobile Phones and Pagers (E, F)
- Newspapers (F)
- Non-diving watches (L, M).
- Non-fire-retardant, bedding including blankets, sheets, pillows, mattresses, etc. except 100% cotton or treated materials. (F)
- Personal entertainment devices (E, F)
- Petroleum based lubricants, greases, fluids (F).
- Sparking toys (E, F)
- Sugar and fine powder and other flammable food stuffs. (E, F)
- Thermal heat patches, hand warmers, pocket warmers (F)
- Thermos flasks (L, P).
- Volatile Drugs (P, F).

C - Possibility of damaging the fabric of the chamber.

D - Contamination of the environment.

E - Explosion risk.

F - Fire source or a combustible substance.

L - Possibility of being broken or damaged by pressure.

M - Will possibly cause a mess.

P – Affects ability of the occupants

Appendix 4 – Acronyms & Abbreviations

ALS - Advanced Life Support
ASME - American Society of Mechanical Engineers
ATA - Atmospheres Absolute
AE - Air Embolism
AGE - Arterial Gas Embolism
BA - Breathing Apparatus
BHA - British Hyperbaric Association
BLS - Basic Life Support
BSAC - British Sub Aqua Club
BS - British Standard
BIBS - Built in Breathing System (includes masks and hood tents)
CAGE - Cerebral Arterial Gas Embolism
CEN - Central European Norm
CEU - Continuing Education Units
COMAH - Control of Major Accident Hazards Regulations 2015
$C0_2$ - Carbon Dioxide
CO - Carbon Monoxide
COSHH - Control of Substances Hazardous to Health
CHT- Certified Hyperbaric Technologist
CHRN - Certified Hyperbaric Registered Nurse
CNS - Central Nervous System
CPR - Cardio Pulmonary Resuscitation
Christo-lube -An oxygen compatible lubricant
CX30 - Comex 30 Treatment table
DCI - Decompression Illness
DCIEM - Defence and Civil Institute and Environmental Medicine
DRDC - Defence Research and Development Canada
DRC - Deck Recompression Chamber
DCS - Decompression Sickness
DP - Design Pressure
DoH - Department of Health
EBAss - European Baromedical Association for nurses, operators and technicians
ECHCO - European Certified Hyperbaric Chamber Operator
ECU - Environmental Control Unit
ECHM - European Committee of Hyperbaric Medicine
EDTC - European Diving Technology Committee
EN - European Norm
EUBS - European Underwater Barometric Society
FFE - Fire Fighting Equipment
F&RS - Fire & Rescue Service
Halocarbon Lubricant 281 - An oxygen compatible lubricant
HBO - Hyperbaric Oxygen
HBOT- Hyperbaric Oxygen Therapy
HBO_2 - Hyperbaric Oxygen
HHH - Hand Held Hose
HSWA - Health and safety at Work Act
HTP - The Hyperbaric Therapy Provider (as defined by the BHA)

Heliox - A breathing mixture of helium & oxygen
HTM - Health Technical Memorandum
ICU - Intensive Care Unit
IMCA - International Marine Contractors Association
KPa - Kilopascal
LED - Light Emitting Diode
LCD - Liquid Crystal Display
Lock - A single chamber compartment
LPM - Litres Per Minute
MDR - Manufacturer's Data Report
MSW - Metres of Sea Water
mm - Millimeters
mAmp - Milli Amp
mmHg- Millimeters of Mercury
Multiplace - A chamber which can accommodate more than one occupant
Monolock - A chamber with only one compartment / lock
Monoplace - A single person chamber with may be filled with air or 0_2
NBBPTR - Negative Bias Back Pressure Tracking Regulator
N2 - Nitrogen
NBDHMT - National Board of Diving & Hyperbaric Medicine Technology
NFPA - National Fire Protection Association
O_2 - Oxygen
Over Board Dump - A system built into the chamber to extract exhaled gas
PDU - Pressure Distribution Unit
PMS - Programmed Maintenance Schedule
PRV - Pressure Relief Valve
PSI - Pounds per square inch
PVHO - Pressure Vessel for Human Occupancy
PPE - Personal Protection Equipment
PUWER - Provision and Use of Work Equipment Regulations 1998
PW - Problem Wound
QA - Quality Assurance
RA - Risk Assessment
RN - Royal Navy (UK)
RN - Registered Nurse
RN61 - Royal Navy Table 61
RN62 - Royal Navy Table 62
SCUBA - Self-Contained Underwater Breathing Apparatus
TUP - Transfer Under Pressure
TP - Test Pressure
Tx- Treatment
UPD - Unit Pulmonary Toxic Dose
USN - United States Navy
USN TT5 - United States Navy Treatment Table 5
USN TT6 - United States Navy Treatment Table 6
UHMS - Undersea and Hyperbaric Medicine Society (United States)
WP - Working Pressure

Appendix 5

Suggestions of titles for Technical EPs that also need to be developed by all facilities.

EPs Technical Section 2

- Loss of the primary oxygen supply (multiplace)
- Failure of the back-up oxygen supply (multiplace)
- Contamination of the oxygen supply
- Loss of main power supply
- Rapid uncontrolled chamber decompression (multiplace)
- Controlled emergency decompression (multiplace)
- Primary communications failure
- Leaking oxygen supply in the LOX compound
- Sudden and significant increase of the chamber pressure (multiplace)
- Contamination of the chamber environment (multiplace)
- Omitted decompression (multiplace)
- Loss of the primary air supply (multiplace)
- Chamber oxygen % level cannot be safely maintained
- Loss of environment monitoring (O_2 CO_2 CO and MSW / FSW / kPa)
- Chamber ventilator failure
- Loss of back up air supply (multiplace)
- Loss of internal surveillance (CCTV)
- Inadequate temperature regulation inside the chamber

EPs Medical Section 3

Suggestions of titles for Medical EPs that also need to be developed by all facilities.

- Patient distress inside the chamber (multiplace)
- Chamber operator distress or incapacity during a treatment
- Management of aggressive, violent or dangerous behaviour
- Convulsions including CNS oxygen toxicity (multiplace)
- Cardiac / respiratory arrest or angina inside the chamber (multiplace) - Respond blue
- Inside chamber attendant distress or incapacity during a treatment (multiplace)
- Pneumothorax inside the chamber (multiplace)
- Cerebral arterial gas embolism (cage) (multiplace)
- Acute claustrophobia/anxiety inside the chamber (multiplace)
- Ear &/or sinus barotrauma in the chamber
- Pulmonary oxygen toxicity
- Asthma attack inside the chamber
- Management of Hypoglycaemia
- Suspected choking
- Management of seizures
- Accidental extubation
- Loss of consciousness
- Vomiting
- Decompression illness in patients or staff

Appendix 6 – Fire Risks and Precautions within Chambers used for Hyperbaric Therapies

The information listed in this appendix covers fire risk which may be experienced in therapy chambers using compressed air environments between 1 and 6 bar (0 - 50 MSW).

Area of Risk	Source	Precaution
1. Raised pressure	a - Fire risks in compressed air environments are greater than in one atmosphere i.e. ease of ignition and rate of burning is enhanced in compressed air atmospheres.	System should be designed to minimise the risk of fire and, in the event of such, procedures and hardware should exist to maintain life and minimise damage, i.e. fire extinguishing devices, BIBS, chamber fire procedures, chamber evacuation procedures.
	b – The physical features of the functional therapeutic chamber multiply the hazards of even a very small fire, by containing personnel and restricting escape. One of the most obvious actions to be taken in the event of a fire would be to evacuate the affected compartment, isolating personnel from the danger of fire and noxious gases. In many cases this will not be practical, or at least hampered by the condition of the patient	Hyperbaric firefighting equipment should be fitted in all chamber locks / compartments.
	c- Decompression obligations may negate, or at least delay, evacuation from the hazardous environment.	

Area of Risk	Source	Precaution
2. Raised oxygen percentage	a - BIBS leaking when administering oxygen enriched gases (>21%)	Correctly fitting oral nasal masks; provide adult and child sizes. Use BIBS, incorporating an 'overboard dump' so exhausting expired oxygen enriched gases from within the chamber. Regularly maintain system, check for leaks prior to use. A flexible extension tube from the internal gas sampling line may be used to discover system leaks during operation.
	b - Atmosphere replenishment	Oxygen replenishment systems should introduce gas into the chamber to facilitate mixing, e.g. oxygen could be bled into external regeneration return lines; onto internal scrubber fans; jetted at short burst into the top of the chamber. Oxygen analysers should be fitted with high and low alarms.
	c - Patient ventilator	Fit scavenge line to the patient ventilator exhaust so drawing off oxygen-enriched gases expired by the patient and dumping it outside the chamber. In all cases chamber oxygen should be maintained below 23.5%; concentrations, above this will require flushing through with air. (If ventilator is driven with oxygen then this will need to be drawn off to the overboard dumps).

Area of Risk	Source	Precaution
3. Flammable atmospheres	a - Dust in suspension in a dry atmosphere	All gas lines should incorporate gas filters; chamber furnishings should be lint free; chamber should be cleaned out daily.
	b - Volatile substances	Spirit based medical wipes are not recommended for use in the chamber. Volatile drugs should be pre-loaded into syringes outside the chamber. Patients, their clothing and bedding should be void of spirit based preparation, aftershaves and perfumes, hair spray, pens containing spirit-based inks (see Appendix 3). All persons entering the chamber should be checked and relieved of these substances. Chamber clothing should be 100% cotton with NO pockets.

Area of Risk	Source	Precaution
4. Flammable Materials	a. Clothing flammability	Chamber occupants should wear 100% cotton (NO pockets) materials, clean and free from oil and grease and unique to the chamber only.
	b. Bedding and chamber soft furnishing flammability	Material of a standard acceptable to hospital use should be employed. Keep all bedding to a minimum, only as required for the therapy.
	c. Food stuffs: flammability low flashpoint	Certain foods are inherently flammable and should not be introduced into the chamber in a raw state e.g. sugar should be premixed into drinks; butter etc. should be pre-spread onto bread.
	d. Lubricants: low flashpoint	Only permitted lubricants should be used within the chamber and on any equipment that maybe introduced into it e.g. ventilators, aspirators, stretchers, etc. All such equipment should be checked and authorised before use by the safety officer.
	e. Paints	Chamber surfaces to be painted with non-toxic materials, and of minimum thickness (1 mm). Flaking paint should be feathered in and patched as soon as possible; thin sections will ignite readily.
	f. Electrical insulation	Use fire retardant insulated wiring and ensure it is protected from damage.

Area of Risk	Source	Precaution
4. Flammable materials (continued)	g. Medical supplies	Flammable materials, such as tissues, medical wipes and bandages, should be kept to a minimum and may be stored in covered metal containers or drawers. Used materials should be passed out of the chamber as soon as convenient.
	h. Paper products	These should be kept to a minimum. Rubbish should be passed out of the chamber as soon as convenient.
	i. Imported items	All personnel entering the chamber, regardless of whether it is to be pressurised or not, should declare all equipment they intend to take in with them so that it may be vetted by the system operator / supervisor / safety manager. A notice containing the following or similar information should be prominently displayed over all entry doors and medical lock doors: **WARNING: FIRE AND TOXICITY RISK** **No flammable or toxic materials, such as lighters, oil containing articles or clothing, are to be taken into the chamber. Instruments containing mercury, are never to be taken into the compression chamber. Remember the flammable and toxic danger from drugs etc.** Staff should be briefed prior to entering the chamber, the above restrictions being enforced.

Area of Risk	Source	Precaution
5. Electrical systems	a. Chamber fires may be caused by electrical defects	Electrical equipment should be kept to an absolute minimum; that which is employed should comply with the relevant regulations and standards. All systems should be protected by RCDs (ELCBs), trips located in the main control area. All systems should be regularly maintained and checked.
	b. Motors i.e. scrubbers	Should be encased in metal, brushless and switched externally.
	c. Switches and connectors	Power supplies should be located outside the chamber and initiated by external switching. Only intrinsically safe switches should be used inside the chamber.
	d. Lighting	Only hyperbaric compatible lighting should be used inside the chamber
	e. Battery powered equipment	Medical equipment normally powered by internal batteries should be kept to a minimum. As a rule, batteries should not be allowed in the chamber (though we know those of certain construction/materials cannot contaminate the environment). Any battery-operated equipment must be tested and / or approved by the manufacturers for hyperbaric use. Lithium batteries are not to be allowed inside the chamber. (see section 2.8 Electrical Equipment)