Guidance on
Hyperbaric Evacuation Systems

International Marine
Contractors Association

www.imca-int.com

IMCA D 052 Rev. 0.1
August 2018

The International Marine Contractors Association (IMCA) is the international trade association representing offshore, marine and underwater engineering companies.

IMCA promotes improvements in quality, health, safety, environmental and technical standards through the publication of information notes, codes of practice and by other appropriate means.

Members are self-regulating through the adoption of IMCA guidelines as appropriate. They commit to act as responsible members by following relevant guidelines and being willing to be audited against compliance with them by their clients.

There are five core committees that relate to all members:
1) Competence & Training
2) Contracts & Insurance
3) Health, Safety, Security & Environment
4) Lifting & Rigging
5) Marine Policy & Regulatory Affairs

The Association is organised through four distinct divisions, each covering a specific area of members' interests – Diving, Marine, Offshore Survey and Remote Systems & ROV.

There are also five regions which facilitate work on issues affecting members in their local geographic area – Asia-Pacific, Europe & Africa, Middle East & India, North America and South America.

IMCA D 052 Rev. 0.1

www.imca-int.com/diving

If you have any comments on this document, please click the feedback button below:

feedback@imca-int.com

Date	**Reason**	**Revision**
May 2013	Initial publication	
August 2018	Section 5.6 updated to harmonise industry guidance and practice.	Rev. 0.1

Guidance on Hyperbaric Evacuation Systems (HES)

IMCA D 052 Rev. 0.1 – August 2018

Appendices

1 Introduction

When a vessel is severely damaged and likely to sink (or subject to other dangers such as a serious fire) there may come a time when it has to be abandoned. For such a situation vessels are required to have adequate lifeboats (or life rafts) on board for all personnel.

In such an emergency, the evacuation of divers in saturation inside a diving system represents a particular problem as they cannot be readily decompressed in order to be evacuated in the same way as other crew members. The divers need to be transferred to a pressurised compartment which can be detached from the diving system on the vessel and launched or floated into the sea.

Therefore for all saturation diving operations a hyperbaric rescue unit (HRU) needs to be provided that, in the event of a vessel (or structure) evacuation, is capable of evacuating the maximum number of divers that the diving system is capable of accommodating then maintaining the divers at the correct pressure with life support for a minimum of 72 hours. Planning and facilities also need to be in place to ensure that, after the initial evacuation, the HRU and its occupants are taken to a designated location where they can be decompressed back to surface pressure in a safe and controlled manner.

The most practical, and most common, way of meeting these requirements is to provide an HRU made up of a pressure vessel mounted inside a conventional lifeboat body. The lifeboat is self-propelled and often uses the engine to provide elements of the life support. Such a unit is called a self-propelled hyperbaric lifeboat (SPHL). At the time of publication of this document a number of HRUs exist (HRCs) that are not self-propelled and while the long term intent of the industry is that all HRUs are self-propelled, it is recognised that these units do provide a means of escape for divers in an emergency although the subsequent requirements for life support and recovery may be much more difficult to comply with due to limitations of design and configuration.

This document aims to provide guidance on minimum requirements needed to achieve these goals and to identify the various factors that need to be considered during the planning phase before diving commences. It also aims to provide guidance on the risk assessment process required to ensure that the necessary standard of safety is achieved.

A number of these sections can be used for checking/audit purposes of specific parts of the hyperbaric evacuation system (HES) planning and risk assessment process. As a result of this approach there is an inevitable duplication of some items in more than one section and it should be understood that in most cases complying with the requirements in one section will also result in complying with this requirement in another section.

This document also seeks to establish standard terminology for the various parts of a hyperbaric evacuation system. Appendices 1 and 2 give lists of acronyms and the definitions for the terms used.

As this document contains many items of technical advice without giving detailed explanations, it is assumed that the reader has knowledge of saturation diving technology, physiology and equipment.

2 Background and Explanation

2.1 Standard Evacuation

When a vessel (or installation) has to be abandoned and there are divers in saturation (living under pressure significantly higher than atmospheric) then these divers cannot be decompressed quickly and need to be evacuated while still under pressure. They then need to be taken to a suitable site at which the decompression can be safely undertaken.

The divers will be evacuated in an HRU which may be a floating chamber (hyperbaric rescue chamber – HRC) or a lifeboat that contains a chamber (self-propelled hyperbaric lifeboat – SPHL) or some other specialised unit. The divers are evacuated in this unit while still under pressure and it is provided with a standard minimum amount gas for the divers' respiration plus other equipment and consumables to ensure their wellbeing.

The normal process for conventional lifeboats or life rafts in an evacuation is that they form into a group (or 'huddle') near the point of the abandonment (although far enough from the emergency to ensure they cannot be threatened by it) and await the arrival of rescuers. Typically they will be fitted with emergency position-indicating radio beacons (EPIRBs) that are activated during the abandonment and can be tracked by a satellite search and rescue system. The exact location details are transmitted to vessels in the region that can then go to the lifeboat huddle position to collect the personnel from the lifeboats or life rafts.

Unlike conventional lifeboats and life rafts this scenario is not suitable for divers evacuated under pressure as they are at much greater risk and require to be taken to a place of safety as quickly as possible. Therefore it needs to be understood by all personnel, onshore and offshore, that the standard evacuation conventions are not appropriate for a hyperbaric evacuation.

The HRU needs to be lifted onto a rescue vessel or allocated installation as soon as possible. If a suitable rescue vessel cannot be guaranteed to arrive in a relatively short timescale to take on the HRU, then the HRU needs to start making its own way (or be towed) towards a location from which it can be safely managed.

2.2 The Necessity for Hyperbaric Evacuation Planning

Very few hyperbaric evacuations have ever taken place which, in the past, has led companies to assume that this means that the likelihood of such an incident is extremely low. However it should be recognised that there have been several incidents in the past where hyperbaric evacuation systems (HES) were not actually available and divers have probably died as a result.

There have also been other situations where the HES was not able to be used, either because of lack of time to enter the system or because damage caused by the incident prevented access to the HES or rendered it inoperable.

Since incidents resulting in the requirement for a hyperbaric evacuation are not only possible but quite foreseeable, it is important that robust hyperbaric evacuation plans are put in place for all saturation diving operations.

2.3 Hyperbaric Evacuation Systems (HES)

The original use of the term hyperbaric evacuation system related only to the equipment that formed part of the diving system and actually evacuated the divers away from the normal diving system. These were typically either a hyperbaric rescue chamber (HRC) – a chamber designed to float, that could be launched and towed away from the damaged system, or a self-propelled hyperbaric lifeboat (SPHL) – sometimes also known as a hyperbaric lifeboat (HLB) or hyperbaric rescue vessel (HRV) – which is a standard type of ship's lifeboat that contains a saturation chamber.

These units have stored gas on board plus other equipment designed to allow the divers to be able to breathe and remain safe despite being disconnected from the diving system. The amount of gas and other equipment dictates the likely endurance of the unit and can vary considerably.

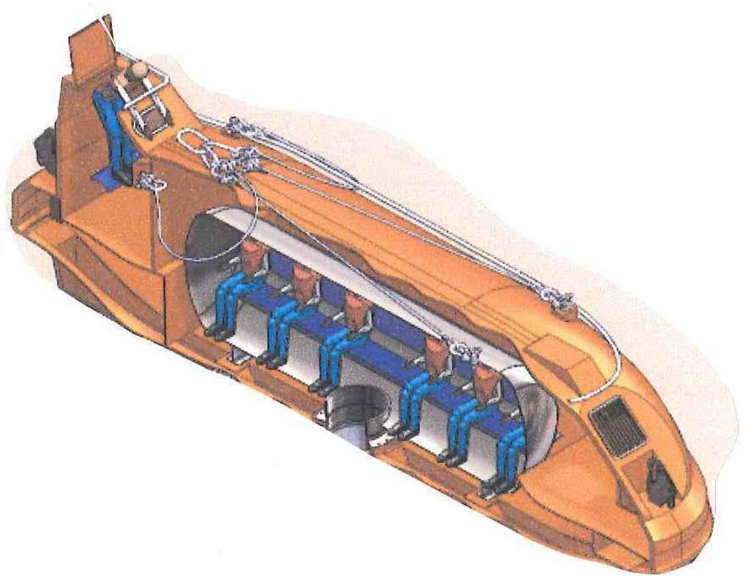


Figure 1 – Cut away section of a self-propelled hyperbaric lifeboat (SPHL), showing the chamber within the lifeboat, the coxswain location in the cockpit, and the divers strapped into their seats

Figure 2 – Hyperbaric rescue chamber

The phrase 'HES' has now been expanded to include all of the other equipment that supports the hyperbaric evacuation arrangements.

This additional equipment covers the following: life support package (LSP) – a life support system that can be connected to the HRU on arrival at the safe haven/reception site, which will provide appropriate external services to support the HRU until the decompression of the divers can be completed at a suitable location, and hyperbaric reception facility (HRF) – a system with a suitable chamber or chambers into which the divers can be transferred under pressure from the HRU, to provide a fully safe and spacious environment in which the decompression can be completed with far greater comfort and far less potential physiological difficulty.

The reception site is the place where the evacuated divers are in safe environmental conditions and transfer can be made to a decompression facility or where decompression can be carried out (or completed) in the HRC or SPHL using external life support facilities (LSP). There are two main types of hyperbaric reception facilities: portable ((P)HRF), which can be deployed to a suitable location for set up; and fixed ((F)HRF), which is a permanent installation to which an HRU can be taken.

Also included in the phrase HES are the policies, procedures, risk assessments and planned maintenance that relate to hyperbaric evacuation and to the associated equipment.

When using an HRF it may be possible to surface the HRU and thoroughly clean it out. The HRU can, if required, be re-mated to the HRF chamber, blown down to the chamber depth and provide an additional area for the divers to improve the comfort of the decompression. The additional chamber on the HRU would be beneficial for longer decompression times, such as depths greater than 150m. Before it can be re-mated and blown down it needs to be clarified that the HRF is adequately supported, has adequate environment control unit capacity, appropriate umbilicals and sufficient gas supplies (additional gas can be ordered following the initial reception if required).

2.4 Hyperbaric Evacuation Concerns

2.4.1 Physiological Issues

Apart from having enough gas to keep the divers alive, the biggest problem with hyperbaric evacuation is being able to maintain the health of the divers in the HRU chamber. Whatever the type of HRU, it will have a relatively small chamber, and the occupants will have to remain strapped into their seats for safety.

The likelihood of fairly severe sea states is high, so seasickness would be a problem, which will lead to dehydration. The aroma of vomit, urine and faeces in the chamber will accelerate the problems.

The confined seating requirements mean the divers will be unable to move around, which will lead to severe discomfort and potential serious physiological impact. So, it will be extremely difficult to ensure that the divers are in a good condition during the evacuation. This could prevent the decompression being commenced, which could extend the time the divers have to spend in the HRU. For example, normal decompression from 130m can take five days.

The standard requirements for the HRU are that there is enough gas and consumables available to ensure 72 hours' endurance. From this it is obvious that, even if the standard decompression was to commence immediately the evacuation was carried out, there may be a significantly inadequate amount of gas and consumables available. If the sea state induces seasickness, etc. which prevents the start of the decompression, and the transit to a safe haven (a place where the HRU can be taken initially as part of the evacuation plan) takes 48 hours then the total time in the chamber is about seven days. Note: The safe haven may also be a reception site or it may be an intermediate stop on the way to the reception site.

Emergency decompression tables are available; however, that would still mean a number of days under those cramped conditions. Note: the Diving Medical Advisory Committee (DMAC) has published guidance DMAC 31 – *Accelerated emergency decompression (AED) from saturation*, however the guidance states that it is not considered appropriate for use in an HRU. It is obvious that one of the main points of the LSP is to provide enough additional gas and consumables to ensure efficient management of decompression.

The benefit of an HRF is that its chamber is likely to be far less confined, allowing the divers to move about, and may permit the treatment of injured personnel who may not have been able to receive appropriate care within the HRU, thus helping to maintain reasonable health and providing a significant benefit of an HRF over the LSP.

The transit to the safe haven, as mentioned above, can lead to the physiological problems mentioned above, so the DMAC 15 – *Medical equipment to be held at the site of an offshore diving operation* – medical supplies requirement is intended to reduce the problems arising from seasickness. The main point is to ensure that all divers take anti-seasickness medication immediately the potential for hyperbaric evacuation arises. To help protect from dehydration, the DMAC specified amount of water needs to be provided for the divers and they have to be instructed to consume it. Also, additional substances in the scrubbers can reduce the unhealthy aromas that can build up in the chamber. These issues will all help, but they will not guarantee avoiding the problems.

These problems can be even more complicated by personnel being injured during the incident that led to the evacuation or even during the evacuation itself. This has to be managed as well as possible, so communications between the life support personnel in the lifeboat cockpit and the diving medical adviser need to be in place.

2.4.2 Chamber Evacuation

In some circumstances, the divers in the different chambers of the diving system may be at different depths when an evacuation is required. This could be because of operating a 'split-sat', where there is a shallow and a deep storage depth, or there may be divers decompressing while others remain at storage depth. It is indeed possible that all three separate depths may be in use at the time of the evacuation.

The HRU generally has a single chamber, so the divers all need to be at the same depth for the evacuation. This normally means that the shallow divers need to be blown down to the deeper (or deepest) storage depth. However, divers in decompression can, if they are shallow enough, and the offshore project manager (OPM) and supervisor are confident there is enough time, be brought to the surface as fast as possible rather than be evacuated under pressure (subject to suitable procedures and tables being available). This situation would be different on a vessel fitted with two separate HRUs, subject to suitable procedures and tables being available. In cases of deeper saturations, consideration needs to be given to the possible relative depths of the divers, in terms of the time needed to pressurise the shallower team to the depth of the deeper team. This should form part of the contingency planning.

It is possible that there may be injured personnel in the chambers who also need to be evacuated, so a suitable stretcher and methods of transferring the injured diver(s) need to be in place.

2.4.3 Transit to Safe Haven

A serious issue with hyperbaric evacuation, however, is being able to get the HRU to the safe haven in a safe and efficient method. This should be as soon as possible and planning should be based on arrival at the safe haven within 75% of the HRU designed endurance.

If the HRU is an HRC, it will not be self-propelled and the availability of a rescue vessel needs to be a fundamental part of the evacuation plan. Ideally, this vessel should be capable of lifting the HRC onto the back deck where it can be connected to an LSP. Under ideal conditions, during the evacuation it may be possible to transfer the HRC directly from the damaged vessel (or barge, platform, etc.) to the rescue vessel. In the worst case, if the weather prevents the safe lifting of the HRC onto the rescue vessel's deck, it may be secured alongside and connected to the LSP, if the weather allows, or, alternatively, simply secured on a tow line. If the HRU is self-propelled then it may still need assistance from a nearby vessel for towing or other reasons. The availability of a suitable vessel within a reasonable timescale should be considered as part of the planning process.

At the present moment, there are a limited number of custom designed systems available for taking an SPHL onto a rescue vessel for the transit, so the main method of transit will be towing if the SPHL trials demonstrate this is safe, or the SPHL's own self-propelled capability. SPHLs may be able to make six knots, although this is not always the case. Assuming six knots is possible, in good weather conditions the SPHL may be able to cover 288 nautical miles in 48 hours but this cannot be taken as likely, so the assumed maximum distance should be 200 nautical miles. If the SPHL can only manage four knots under the best weather conditions, then 190 nautical miles is the best possible, so a maximum of 150 nautical miles applies. The possibility should be considered of securing the SPHL to the side of a vessel in a safe manner that can increase the transit speed.

A system for recovering the SPHL onto a rescue vessel should be looked into and that should include an LSP on the vessel to ensure life systems remain operational during the transit.

In Norwegian waters there are three rescue vessels. One is the Havila Troll. Standard ships' lifeboats can be recovered onto this rescue vessel, their occupants transferred and the lifeboat returned to the sea. The last lifeboat to be recovered would be the SPHL. The Havila Troll has an LSP built in, so the SPHL will be connected to maintain the chamber environment during the transit to the HRF in Bergen. All of this is standard within Norwegian waters but is not currently available elsewhere.

The information on the Havila Troll is an example of how the industry may be able to move forward. In the meantime, the towage or self-propelled transits needs to be considered the most normal.

However, if a guiding/support vessel cannot be guaranteed to be available, the SPHL needs to be able to be navigated safely to the safe haven. The recommended method for this is a suitable global positioning system (GPS). The GPS should have potential safe haven locations programmed in so that, following an evacuation, the coxswain can activate the GPS, identify the required location and the GPS will provide the necessary course, as well as amending the course during transit. In order to ensure that this can be done the coxswain, as a minimum, should be fully trained in the use of the GPS as well as qualified as per the International Convention on Standards of Training, Certification & Watchkeeping for Seafarers (STCW). Consideration should also be given to training the other SPHL crew members to ensure a long duration transit can be safely managed. The SPHL should be fitted with an EPIRB, so that its location can be tracked, and communications that will ensure the SPHL crew can always be in contact with personnel that can advise on transit details as required.

Other issues should be considered as part of the basic requirements for transit. Since there is a limited duration of the gas supplies on the HRU, a method of getting additional gas to the HRU during its transit should be identified, which could enable the endurance of the HRU to be extended and reduce the likelihood of running out of gas. Additional supplies for the HRU could also include extra sodalime (CO_2 scrubbing material), medical supplies, fuel, water and food, as well as replacement or relief personnel for the HRU crew.

The method of transporting these extra supplies should be a fast craft or vessel with enough space onboard for gas storage and extra personnel. It should be stable enough to minimise the potential problems of seasickness.

There should be an acceptable method of securing the HRU alongside, with adequate fenders to ensure no damage can occur to the HRU hull, and a resilient hose system should be in place for the gas transfer. Also, it may be possible for this (or another larger) vessel to provide a significant lee during the gas transfer, reducing the exposure to severe sea states.

The transit to the safe haven can be enhanced by assistance from other vessels. For example, a vessel that can take out the additional gas, etc. as detailed above, could be a platform supply vessel (PSV). These can often do 14 to 15 knots, so can leave port and arrive at the HRU far sooner than the HRU could arrive at the safe haven. Under ideal circumstances, a PSV or reasonably sized vessel already in the area can be asked to go close to the HRU to provide a lee which could reduce the extent of seasickness. Any of these vessels will have a standard navigation system so they can operate as a guide for the transit, taking some of the stress off the HRU crew.

For non-hyperbaric evacuation, the standard process is for the conventional lifeboats or life rafts to form a 'huddle' in close, but safe, proximity to the point of evacuation. As explained earlier this is not suitable for an HRU as it has to reach the safe haven/reception site in good time to ensure the gas supply and consumables on board do not expire. Part of the decision to be made at the start of the evacuation is for the Master and OPM or supervisor (or the next in line if they are not available) to determine whether it is safe to retain the HRU with the other lifeboats/life rafts, or to instruct the HRU crew to commence transit to the safe haven immediately. The issues that will dictate this decision are:

- Are there suitable support or rescue vessels in the immediate vicinity that can provide an LSP or equivalent support?
- Are there suitable vessels within a reasonable vicinity that, on arrival, can provide assistance in the transit by providing a lee, guiding the vessel, or if appropriate, by providing a tow for the HRU?

To assist these decisions the client should be able to provide information on in-field support vessels such as platform supply vessels (PSVs), diving support vessels (DSVs) or standby vessels, or others within a few hours of the location.

Also, emergency communications systems may result in vessels in the vicinity being alerted to the situation (refer to International Convention for the Safety of Life at Sea (SOLAS) Chapter V Regulation 33 for information on this). Such vessels, under this regulation, are required to provide assistance and to proceed to the evacuation location to rescue the personnel from the lifeboats or life rafts, and to provide a lee, guide and tow (if available) for the HRU.

If it is not possible to get support vessels to the HRU in time to ensure the gas supply and consumables endurance is not threatened, the HRU should depart immediately for the safe haven. Suitable vessels that can be supplied will then intercept the HRU in its transit as soon as possible. The worst case is where there are no other vessels in the vicinity and the HRU may have to remain unattended until arrival at, or close to, the safe haven.

2.4.4 Serious Weather Problems

As is identified above, the transit to the safe haven relies on the HRU being able to make its own way there, or preferably being assisted by a suitable vessel.

If the evacuation occurs in severe weather, with strong winds coming from the wrong direction, then the possibility of the HRU being able to transit to the intended reception site is reduced. Alternative methods of transit, or alternative locations for reception sites should be looked into at the planning stage.

2.5 Hyperbaric Evacuation Planning

Each project that involves saturation diving operations needs to include hyperbaric evacuation planning in the project preparations. Although the following information relates mainly to SPHLs, the same basics will also be applied to HRCs.

Initially identifying whether or not the reception site needs to be put in place should be identified and will be dictated by the distance from the nearest fixed hyperbaric reception facility. An agreement would normally be put in place that ensures that the HRF system is available for any HRU reception, with procedures and vessel dedicated equipment in place.

As part of every project preparation, it is recommended that a meeting takes place to agree the hyperbaric evacuation requirements. This should be captured in the risk assessment process.

If a reception site is agreed as being required, then the site required details need to be prepared. This will include identifying the suitable location for the storage and set up of the LSP or (P)HRF. If it is unlikely that the HRU will be within a reasonable transit distance of a shore based safe haven and/or reception site, it should be possible to identify a suitable offshore asset within reasonable transit distance of the worksite on which the LSP or (P)HRF can be set up. Suitable assets could include FPSO, platform, barge, etc. The client needs to accept and support this, with the confirmation of adequate deck space, crane capacity and asset safety. In addition, if the asset is a production platform (for example), the client may need to be prepared to shut down or partially shut down the platform in the event of an HRU (which would not be suitable for locating in hazardous area) being taken there.

The planning for the reception site needs to include the identification and recording of all the assets, resources and supplies that are available at the location. This will include a suitable crane, power supplies, water supplies, food supplies for the chamber occupants and human effluent management, accommodation and food for the life support team and dive techs, etc. If there are suitable personnel available, for example if there is a hyperbaric facility (not an (F)HRF) or another diving contractor in the vicinity that has on call life support personnel, they should be informed of the potential request for their help in dealing with an emergency. All the relevant contact details should be included in the bridging document, a copy of which needs to be placed in the HRU, and LSP or HRF container. All of these details should also be included in the project specific hyperbaric evacuation procedure.

If the reception site cannot be established at the quayside at which the HRU will arrive, then a method of transporting the HRU to the reception site needs to be included in the plan.

If it is the intent to mate the HRU to an HRF then it is recommended that a trial mating should have taken place and be documented. Similarly a test should have been carried out to confirm that the emergency connectors on the HRU and LSP are compatible, particularly that the electrical connectors are wired up in the same way. Typically this will be done using a dummy test panel.

Other aspects of the potential requirements for hyperbaric evacuation should be captured. Examples of general aspects are:

- The potential for an incident resulting in a hyperbaric evacuation can occur at any point between the mobilisation port and the demobilisation port. For example, if a vessel has only recently left port for a work site 250 miles distant but the vessel is involved in a collision 30 miles out and is sinking, then the HRU may be much better heading back to the port rather than the designated HRF which may be much further away;
- A portable HRF is set up at one location. Any diving activity being carried out within an agreed radius of that location will use the (P)HRF as its reception site. This can also be extended to include a radius from a location to which the (P)HRF can be deployed in the event of an emergency, in time to be set up to receive the HRU;
- If an incident occurs during a transit and the HRU is closer to another reception site than its planned one, then that site should be used;
- When operating at extremely remote locations, the vessel may be so far from the shore that the reception site needs to be set up on an asset within safe distance of the worksite. The suitable location should be agreed with the client, who will need to ensure that adequate space and suitable cranes are available.

Contact details for all of these aspects need to be included in the project specific hyperbaric evacuation procedure and the bridging document.

2.6 Personnel for Hyperbaric Evacuation

One of the most important factors to be considered is the need to have enough suitably competent personnel available to assist with the hyperbaric evacuation, transit, reception and subsequent decompression of the divers.

At the point of evacuation, there will normally be suitable personnel present who have been managing the divers in the saturation system. However, as explained earlier, it is important that there are clearly defined protocols as to who is responsible for what at the point of evacuation.

After the initial evacuation, the number and competence of personnel required will depend on the plans for action. This subject is covered in more detail in section 10.

3 Medical Aspects of Hyperbaric Evacuation

3.1 Introduction

The evacuation of divers from a saturation diving system represents a major emergency.

Irrespective of the type of evacuation system, most evacuated divers will be subjected to similar conditions which will affect their well-being. The more sophisticated systems may be better equipped to deal with the effects of the environment the divers are in but this document describes the medical conditions which may be expected and some options for remedies and measures to reduce their severity.

This document assumes that divers entering an evacuation system are in a relatively normal physiological state (albeit extremely apprehensive). It does not address the final decompression of the evacuees although physiological factors that could influence safe decompression are identified.

This document is not meant to be a medical treatise but is written to provide general operational guidance to address the medical aspects of hyperbaric evacuation. The configuration and type of evacuation system in use as well as geographical factors may affect the nature of the medical issues encountered and the extent to which the measures described can be used. The diving contractor should consult their medical advisers for specific guidance if required.

3.2 Medical Aspects

In broad terms there are four main conditions that can be anticipated from the evacuation process:

- thermal imbalance;
- motion sickness;
- effects of divers' metabolic waste products (bio-effluence);
- consequences of severely restricted movement in cramped and confined conditions.

3.2.1 Thermal Imbalance

The requirement to equip a hyperbaric rescue system with means to maintain thermal balance of the occupants is included in the IMO Resolution A.692(17) – *Guidelines and specifications for hyperbaric evacuation systems*.

Section 8.1 of the resolution states:

> "Means should be provided to maintain all the occupants in thermal balance and in a safe and breathable atmosphere for all environmental conditions envisaged – air temperature, sea temperature and humidity – and with the maximum and minimum number of divers likely to be carried. In determining the durations and amount of life support necessary, consideration should be given to the geographical and environmental conditions, the O_2 and gas consumption and CO_2 generation under such conditions, the heat input or removal and the emergency services that may be available for the decompression of the divers. Gas losses as a result of toilet facilities which discharge to outside the hyperbaric unit and medical lock operation should be taken into account in determining the amount of gas required. The effects of hypothermia should be considered and the effectiveness of the arrangements provided should be established as far as practicable under all conditions envisaged. However, in no such case should the duration of the unit's autonomous life support endurance be less than 72 hours."

Information note IMCA D 02/06 – *The evaluation and testing of the environmental control of hyperbaric systems*, and its accompanying technical note, provide guidance on:

- establishing a thermal testing baseline for the hyperbaric rescue unit (HRU) from which extrapolations can be made for its use in different ambient conditions;
- thermal testing without the need for manned intervention;

- undertaking trials on mixed gas;
- addressing the capability of the HRU to cope with increased heat load in tropical climates;
- providing suitable equipment for accurate environmental measurement;
- addressing the duration that habitable conditions can be maintained in the event of failure of the environmental control systems;
- development of specific hyperbaric emergency procedures.

Testing of the HRU in accordance with the IMCA technical note will determine if thermal balance can be maintained under the most unfavourable conditions. The risk of hypothermia is greatest in cold climes at deeper depths with the minimum number of occupants in the HRU. Hyperthermia is a greater risk in warm climes, shallow depths with the maximum numbers of occupants in the HRU. Both hypothermia and hyperthermia are life-threatening conditions and it is essential that the HRU is adequately equipped to maintain thermal balance in the environment in which it operates. Failure to do so will have catastrophic consequences.

Equipment in the HRU to address the risk of hypothermia may include survival suits. These heavily insulated suits are effective in minimising heat loss from the divers' bodies. Their effectiveness is significantly reduced if they become wet or water-logged or if they are opened. It is conceivable that wetting of the suit may occur from urine, faeces and vomit. Suit opening could be required to use urine or vomit bags. Divers may also need to open the suit to free their arm to operate equipment, use the medical lock, change scrubber canisters and so on. It is therefore extremely important that the HRU has adequate heating systems to minimise the need for passive survival suits. If passive survival suits are required, they should be of the type that has arms and has a glove arrangement that can be easily opened to allow the use of fingers and thumbs. The need to open the suit to urinate could be minimised by using a 'Convene' urinary sheath type device with outlet tube connected to an opening in the survival suit.

3.2.2 Motion Sickness

Motion sickness occurs when the brain receives conflicting information regarding the position and orientation of the body with respect to its surroundings. This has been described as 'neural mismatch'. Various sensory organs are involved.

- eyes, perceiving visual information;
- semi-circular canals in the inner ear, perceiving angular acceleration in all directions;
- otolith organs in the ear, perceiving linear accelerations of the head and the direction of gravity relative to the head;
- other sensors (in the skin for example) sensing movement and position of other parts of the body.

Motion sickness and more specifically seasickness is clinically manifested as nausea and vomiting, associated with secondary symptoms of stomach awareness, drowsiness and sometimes salivation. Other signs include pallor, changes in respiratory rate and heart rate. The onset and degree of seasickness may be affected by external factors such as smell and the sight and sound of others suffering.

A number of studies into evacuation by totally enclosed motor propelled survival craft (TEMPSC) have identified seasickness as a serious problem which can have debilitating effects on the occupants. The onset of sickness can occur rapidly with many suffering within the first 30 minutes. The main triggers for vomiting apart from the motion were reported to be heat and the sight and sound of others vomiting. Seasickness was evident even in relatively benign sea states.

It is reasonable to assume that the results from studies on TEMPSCs are applicable to HRUs and that evacuated divers plus any support crew will suffer from seasickness. Other studies have examined the contribution of the design of the TEMPSC to seasickness. Their results suggest the sitting position of the divers in a typical HRU (sitting sideways to the vessel) and with poor visual reference due to a lack of windows results in sensing severe motion via their balance organs, while their eyes signal no motion at all in relation to the inside of the chamber (high level of neural mismatch). If the HRU has a surface cockpit, it is likely that the surface crew would be facing forward and be able to get some visual cues from the external environment. Nevertheless, it is highly likely that the surface crew will suffer seasickness to the extent that their ability to function effectively is impaired.

3.2.2.1 Effects

The most obvious effect of seasickness is vomiting but this is normally preceded by a sequence of symptoms. There is considerable individual variation in the dominance of certain signs and symptoms. The earliest symptom is typically an unfamiliar sensation of abdominal discomfort, described as 'stomach awareness'. A feeling of warmth and skin flushing may occur but more commonly pallor, cold sweating and increased salivation tend to precede nausea and vomiting. Once the stomach content has been emptied, retching may continue.

Repeated vomiting may lead to dehydration although this may be partially offset by a reduction in urine production (caused by increased release of anti-diuretic hormone (ADH)).

Seasickness may alter the behavioural state of those affected. Feelings of apathy and depression can be so severe as to render the individuals incapable or unwilling to carry out allotted duties or even to take basic measures to ensure the safety of themselves or their colleagues.

Vomiting will introduce acidic gases in the HRU atmosphere. The concentration of the acid in the atmosphere will depend on the number of occupants, volume of the HRU and degree of vomiting. Research has indicated that toxic levels may be reached if a scrubbing (removal) mechanism is not used.

It is possible to reduce the acidic levels in the atmosphere by vomiting into a bag which contains a gelling agent which reduces off-gassing. An example of such a bag is the Absorbeze Maxi-sick bag. The bag also has a sealing mechanism that further reduces the escape of acidic fumes. Used bags can therefore be sealed and disposed of within a plastic waste bag. Care needs to be taken if the bags are passed out in the medical lock or are kept in the deck decompression chamber (DDC) during decompression as they rupture if gas is trapped in the bag.

Acidic gases in the atmosphere can be scrubbed by sodalime (generic term for Sodalime, Sodasorb, etc.). This is of course already present in the scrubbers in the HRU. Additional scrubbing of the acidic gases can be achieved by using impregnated activated charcoal such as Molecular Products' Chemsorb 1202. Ideally the charcoal and sodalime should not be used in the same scrubber basket. The carbon's adsorption of water can reduce the effectiveness of the sodalime in CO_2 scrubbing. Conversely, the water generated by the reaction of sodalime with CO_2 reduces the effectiveness of the charcoal. If only one scrubber is available, the charcoal should be layered so that gas flows over it before flowing through the sodalime. The best configuration is to use separate scrubbers for the sodalime and charcoal.

3.2.2.2 Prevention

If it is accepted that seasickness will be suffered within a short period in the HRU, it is important to consider means of preventing it or reducing its severity.

There are two main groups of drugs used to prevent and treat seasickness:

- antimuscarinic drugs;
- antihistamine drugs.

The first group, the antimuscarinic, is thought to be the most effective and to produce fewer side effects.

Hyoscine hydrobromide is in the antimuscarinic group and is thought to be the most effective prophylactic (preventative) agent for the prevention and treatment of seasickness. The duration of drug action ranges from hours to days, depending on the route of administration.

The routes of possible administration are:

- oral ingested tablet (0.3 mg), taken if possible 30 minutes before start of exposure to motion, repeated every 6-8 hours as required;
- buccal tablet (0.6mg), direct absorption through the lining of the mouth and buccal cavity. Buccal tablets are not readily available;
- intramuscular inject (0.2mg);
- transdermal patch (typically 0.5mg per 72 hours, apply 5-6 hours before exposure to motion. Replace every 72 hours if necessary. Applied as a small patch behind the ear.

The time lag between administration and onset of action differs for the method of administration. The fastest is by injection (approximately 15 minutes), followed by buccal tablet (approximately 30 minutes) followed by oral tablets (approximately 60 minutes) followed by transdermal patches (approximately two hours). Buccal tablets are not readily available and administration by injection is not practical under many circumstances. It is therefore recommended that as soon as the requirement to evacuate becomes a possibility, the divers and crew of the HRU should ingest an oral tablet and apply a transdermal patch. If the emergency situation is resolved, the patch can be removed. If evacuation is necessary, further tablets can be administered as required every eight hours but vomiting may well eject the tablet. If applied sufficiently early in the process, the transdermal patch may remove the need for additional medication by tablets.

Side-effects have been reported with the use of Hyoscine. In most cases the effects are minor; they include dryness of the mouth, drowsiness and occasionally blurred vision. The patches can occasionally cause skin irritation.

3.2.2.3 Summary

Seasickness will almost certainly be suffered by the occupants of an HRU. The effects could be debilitating. It is likely that the surface crew will be affected as well as the divers in the DDC.

A dose of preventative medication should be taken when the possibility of evacuation becomes real. Stocks of orally administered Hyoscine should be kept in sat control and passed into the divers before the start of the evacuation process. Transdermal patches should be applied at the same time. Stocks of oral Hyoscine and transdermal patches should be kept in the HRU for administering while afloat.

If Hyoscine is not available in certain areas, it should be substituted by an available motion-sickness targeted anti-emetic drug.

Sealable bags for vomit (if possible with gelling agent) should be stored in the HRU and double-bagged once used.

Acid gas scrubbing can be improved by using impregnated activated charcoal as well as sodalime.

3.2.3 Metabolic and Waste Products from Divers

3.2.3.1 Carbon Dioxide

Carbon dioxide is a product of metabolism. It can be scrubbed from the atmosphere by sodalime. As a rule of thumb, six kilograms per diver per 24 hours is required. An 18-man HES will therefore require substantial supplies of sodalime (108 kg/day). Carbon dioxide is a powerful respiratory stimulant. Elevated levels in the atmosphere will cause rapid breathing, which of course does not reduce the blood carbon dioxide levels. The effects can be an exhausting ever-increasing breathing rate with panic and eventual unconsciousness.

New types of scrubbing material are under development as a result of experience in space and submarine technology. It is conceivable that these may offer advantages in terms of performance and quantity requirements. Details will be included in subsequent guidance when available.

3.2.3.2 Ammonia

Ammonia is produced through the metabolism of proteins. It is present in very small concentrations in exhaled gas and sweat. It is released in higher concentrations from urine and faeces. Estimates of its total production range from one to two grams per man per day. The release of ammonia into the atmosphere can be significantly reduced by using the toilet facilities if fitted or if not, by urinating into sealable bags containing a gelling agent. The need to open the suit to urinate could be minimised by using a 'Convene' urinary sheath type device with outlet tube connected to an opening in the survival suit with an external tube which can be directed into a gel bag.

The ammonia can be scrubbed from the atmosphere by using impregnated activated charcoal (e.g. Molecular Products' Chemsorb 1425 or 620). 500 grams of the compound will adsorb approximately 25 gms of ammonia. Ideally the charcoal and sodalime should not be used in the same scrubber basket. The carbon's adsorption of water can reduce the effectiveness of the sodalime in CO_2 scrubbing. Conversely, the water generated by the reaction of sodalime with CO_2 reduces the effectiveness of the charcoal. If only one scrubber is available, the charcoal should be layered so that gas flows over it before flowing through the sodalime. The best configuration is to use separate scrubbers for the sodalime and charcoal. One scrubber can be used to hold different types of impregnated charcoal; if possible they should be separated by a porous barrier (cotton cloth, for example).

3.2.3.3 Carbon Monoxide

Carbon monoxide is a by-product of the body's metabolic processes (principally, from the breakdown of haemoglobin). Exhaled gas contains small quantities of carbon monoxide in the range of 1 to 5 ppm. The total amount introduced in the atmosphere is in the order of 20-80 mg per man per 24 hours. The closed atmosphere within the HES will result in elevated levels of carbon monoxide, which may approach or exceed maximum permissible levels throughout the duration of the evacuation process.

Carbon monoxide can be scrubbed using a catalyst which converts it to carbon dioxide. Such scrubbing material is often used in welding habitats and is available for diving applications; one example is 'Sofnacat', which is platinum based but other types are available which may be suitable. It can be included as a thin layer (2 cm) within the sodalime or charcoal scrubbers. The performance of the catalyst is reduced when damp. Ideally, gas should flow over the catalyst before flowing over sodalime because the water produced by the reaction of the sodalime with CO_2 can affect the efficacy of the catalyst. If possible, one scrubber should be used for sodalime and a separate scrubber for the activated charcoal and catalyst.

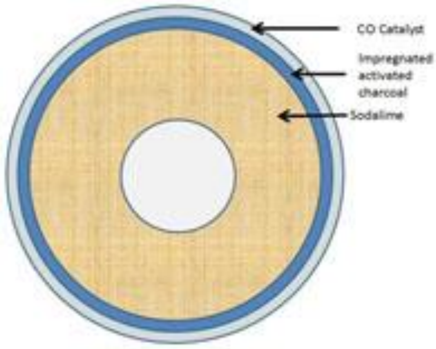
3.2.3.4 Other Contaminants

The contaminants that give cause for most concern have been described above. It is possible that other contaminants (principally organic compounds) may be introduced into the atmosphere from materials within the HES and from the divers' metabolisms. The activated charcoal scrubbing agents identified above will adsorb sufficient organic compounds to acceptable levels.

3.2.3.5 Summary

Gaseous contamination of the atmosphere in the HRU will occur. The principal contaminants will be:

- ♦ carbon dioxide;
- ♦ ammonia;
- ♦ carbon monoxide;
- ♦ organic compounds.



Effective scrubbing materials are available to remove the gaseous contaminants. However, the relative positioning of the scrubber's agents can affect their performance. If possible, sodalime should not be in the same scrubber as activated charcoal and platinum catalyst. The HRU/HRF should therefore have at least two scrubbers. The common use of radial flow scrubbers (gas enters from all sides of the canister towards the centre) means that layering of the scrubbing agent in a single scrubber is ineffective. A better configuration of the scrubbing agents within a radial flow scrubber is shown above in the sketch of a cross section of a radial scrubber basket.

It is possible to use mesh bags positioned towards the other edges of the scrubber canister to hold the charcoal and catalyst so that gas flows over these chemicals before it makes contact with the sodalime.

The source of contamination can be reduced by using sealable gel bags for vomit and urine.

Significant quantities of the scrubbing material need to be stored in the HRU.

The ability of the HRU occupants to change and replenish scrubber material may be affected by the malaise from seasickness and possible violent motion of the evacuation craft.

The supply of 'clean' gas to the divers via the built in breathing system (BIBS) from onboard gas is extremely limited (in the order of minutes depending on depth). It is therefore essential that all reasonable measures are implemented to maintain a breathable atmosphere.

3.2.4 Immobility

The physical environment within an HRU is cramped, the occupants are strapped to their seats and movement is therefore very restricted. The motion of the craft will make it very difficult and dangerous to move around within it. The duration of enforced immobility will depend upon the rescue contingency planning but may extend to as much as 36 to 72 hours in certain locations. In calm conditions there may the opportunity to leave seats but even so, there is very little room for movement.

Prolonged immobility can lead to serious medical conditions. Deep vein thrombosis (DVT) in the blood vessels of the lower leg may result from pooling of the blood in the lower limbs. The pooling may occur because there is no muscle activity around the venous system to assist the conduit of blood through the veins back towards the heart. The restriction in venous return can be made worse by compression of the veins over the edges of seating in the HRU. The circulation may be further compromised by dehydration (heat stress and vomiting) causing increased viscosity of the blood. Clots that detach from blood vessel walls can be carried in the venous return to the heart and passed through to the pulmonary circulation where they cause pulmonary embolism.

Signs and symptoms of DVT include pain in the calf muscles, swelling of the lower parts of the leg(s), raised temperature and increased pulse. The risk of DVT formation can be reduced by exercising the lower part of the leg and by periodically flexing and relaxing the muscles of the calves and shins. Seating arrangements in the HRU should be such that the divers are not sitting on hard edges and corners at the knee joint. Divers should shift position frequently if possible to avoid prolonged pressure on the same point of the lower side of the thighs. The use of anti-embolic (flight) stockings may be considered but these would have to be donned before dressing into any survival suit garments.

The occurrence of pulmonary embolism is a life-threatening event. Symptoms may include chest pain, slowing of heart rate, breathlessness, coughing up blood stained sputum, distension of neck veins, shock and sudden death. Recompression will not have a beneficial effect because the embolus is a clot, not a gas bubble. It is very unlikely that treatment could be administered while the HRU is afloat because it involves specialist administration of anti-coagulants and thrombolytic drugs.

The medical personnel at the HRU reception centres should be aware of the possibility of the triggering of clot release by the movements of the divers transferring to a reception facility.

Prolonged sitting with shallow breathing with restricted mobility can lead to an accumulation of bronchial secretions in the lungs. The risk can be reduced by encouraging bouts of deep breathing, coughing and expectorating. Fluid intake should be maintained to minimise mucous viscosity.

3.2.4.1 Summary

Prolonged seating can increase the risk of DVT. Leg exercises should be performed at least hourly to reduce the risk.

The use of flight stockings can help reduce the blood pooling in the lower legs.

The presence of DVT can cause a significant increase in the risk of pulmonary embolism.

Divers should perform periods of deep breathing for about 30 seconds every 15 minutes if possible.

Divers should maintain fluid intake though frequent ingestion of water and isotonic drinks (100-150 ml/hour).

3.3 Medical Supplies

DMAC has published guidance on the recommended medical supplies to be stored in the HES – DMAC 15 – *Medical equipment to be held at the site of offshore diving operations*. Please refer to the DMAC website for the most up-to-date version of DMAC 15 – www.dmac-diving.org

3.4 Conclusion

The process of hyperbaric evacuation can cause serious medical problems for the divers and any support crew in the HRU. The effects of the medical problems can be reduced if certain measures are taken prior to and during the evacuation process:

- Pre-evacuation administration of oral Hyoscine and application of transdermal patch;
- Supplies of oral Hyoscine and patches held within the HRU;
- HES to be equipped to maintain thermal balance. This may involve the use of passive survival suits. Suits should be of the type that allows hands to be exposed;
- All toilet activities to be performed in a toilet system that takes the effluence out of the chamber or, if this is not possible, into sealable gel bags that should be locked out of the chamber;
- Urinary sheaths should be considered to transport urine to a gel bag without the need to open the suit;
- Vomiting should be into sealable gel bags that should be locked out of the chamber;

- Scrubbers should be configured to accommodate catalyst to remove carbon monoxide, impregnated activated charcoal to scrub acid gases and ammonia and sodalime to remove carbon dioxide;
- The HRU/HRF should be configured to allow two separate scrubbers for the charcoal/catalyst compounds and the sodalime;
- Sufficient quantities of the scrubbing materials need to be held in the HRU to match the anticipated duration;
- Sufficient spare scrubber canisters should be pre-charged and kept in sealed bags to allow rapid and easy change-out when necessary;
- Divers may be debilitated to the extent that they cannot perform the action that may be required of them (valve operation, scrubber change out, etc.);
- Fluid intake needs to be maintained, as rule of thumb, 100-150ml per man per hour;
- Isotonic drinks can be given to the divers to help counteract the effects of electrolytic imbalance;
- Anti-embolic stockings to be included in the survival equipment and donned as part of the preparations for evacuation;
- Divers need to move if possible and shift position. They should at least perform regular lower leg extensions and flexing and relaxing of the muscles of the lower legs;
- Divers should perform deep breathing periodically (30 seconds every 15 minutes);
- In-chamber and hourly action cards should be prepared and kept in the HES and surface compartment;
- The training of the divers in emergency procedures should be expanded to include the information contained herein;
- The combined effects of the evacuation process are likely to severely compromise the divers' physiology. Therefore decompression should not be 'automatically' instigated unless there is an immediate danger to life by remaining under pressure. An uneventful decompression is more likely once the HES is in calm waters and possibly attached to a reception facility, the divers' acid-base balance has been restored and the divers are adequately rehydrated.

3.5 References

The following are reference documents used to establish a number of the facts and requirements contained in this section. If further information is desired then consult the reference documents for full details:

- IMO Resolution A.692(17), 1991 – *Guidelines and Specifications for hyperbaric evacuation systems*;
- IMCA D 02/06 – *The Evaluation and testing of the environmental control of hyperbaric evacuation systems*. 2006;
- Reason JT, Brand JJ, (1975) – *Motion Sickness*. London. Academic Press;
- UK HSE Report OTH 94 462 – *Medications for the treatment of motion sickness during evacuation, escape and rescue offshore*;
- Landolt JP, Monaco C (1992) – *Seasickness in totally enclosed motor propelled survival craft: remedial measures*. Aviat.Space Environ.Med. 63:219-225;
- NUTEC (now NUI) report 29-92 – *Hyperbare redningsenheter – Kjemiske miljoaspeketer*, 1992;
- Malvik B, *Cleaning of saturation chamber breathing atmospheres.* Trondheim: SINTEF UNIMED, 2002; STF78 F0021047;
- Tipton M, Newton P, Reilly T, *The estimation of the metabolic production of carbon dioxide in hyperbaric evacuation systems*, University of Portsmouth (available from IMCA);
- Jacobsen E, Vaemes RJ, Segedal K. Time margins during hyperbaric evacuation. Bergen: Norwegian Underwater Technology Centre AS 1993 (in Norwegian);
- DMAC 015 – *Medical equipment to be held at the site of offshore diving operations*. Refer to DMAC website for current version www.dmac-diving.org
- DMAC 031 – *Accelerated emergency decompression (AED) from saturation*

4 Elements to be Considered in the Development of a Hyperbaric Evacuation System

This section contains a checklist of the various elements which require to be considered and addressed during the development of an HES. It does this by means of questions or statements of requirement and it is intended that this section will be completed electronically with an explanation or response in each of the **Remarks** boxes on the right hand side (this may be by identifying a supporting document). The completed section will then form part of the documentation used to risk assess and provide assurance on the HES.

Item	Point	Notes	Remarks
1	**Concept of HES**		
1.1	Concept	Identify need – numbers and depth	
		Decide on HRC or SPHL	
		HRC typical on mobile systems used on barges, rigs or vessels of convenience	
		SPHL typical on permanent DSV installation	
		Consider operating environment for thermal balance provision	
		Will it go to HRF or use LSP – or can it do both?	
		Is it able to be launched rapidly?	
		Is it to be used in one location or world-wide?	
		What duration of on-board support is intended?	
		Will there be a dedicated rescue vessel or local lift off?	
		Are two means of evacuation required?	
2	**Design of HES**		
2.1	Class	Define/select the classification society to be used	
		The dive system should be classed	
		If not to be classed it should be built to classification society rules	
		Is it intended for a vessel or installation that is classed?	
2.2	IMO/flag state	Is the installation/vessel covered by IMO?	
		Are there any flag state requirements?	
		Does SOLAS apply?	
2.3	Industry guidance	Is any specific industry guidance being used?	
		Does it meet IMCA guidance?	
		Does it comply with other guidance such as OGP/ADCI?	
2.4	Regulations	Which country's regulations apply?	
		Do these regulations have any specific requirements?	
2.5	Functional specification Note: This should include a reasonable level of contingency and should set performance standards	Is it a dedicated HRU or dual function (HRU and living chamber)?	
		If dual function is the changeover configuration suitable for quick and easy management?	
		Is it to be self-propelled or float away and towed?	
		Is the LSP easy to unpack and use?	
		Is the LSP robust and packaged to be easily transportable?	
		Is the LSP designed to provide essential life support for a defined period?	

Item	Point	Notes	Remarks
		Does the LSP come with sufficient redundancy for foreseeable breakdowns?	
		Are there enough supplies in the LSP to be self-contained for the defined period plus spare?	
2.6	Specification Note: Specifications should be produced for all components such as HRU/LSP/HRF/support vessel, etc.	Are there any specific interfaces required – flange dimensions/position; lifting points; external connections/restrictions – on the LSP?	
		Is it designed to recognised international standard and a classification society's rules?	
		Ability to carry maximum complement of divers in saturation and any necessary support personnel at atmospheric pressure	
		Ability of system (trunking/manways, etc.) to allow transfer of injured diver on a stretcher from dive system in to the chamber	
		Launch and recovery loadings and stresses	
		Depth capability for maximum saturation depth	
		Ability to provide life support for a specified minimum period	
2.7	Maintenance (including marine equipment items)	Designed for ease of maintenance	
		Consider access restrictions	
		Provide ability for regular maintenance	
2.8	FMEA/FMECA	Carry out FMEA/FMECA against design specification	
		Carry out HIRA on all HES activities	
		Consider all foreseeable situations including: list at launch, likely damage in an emergency, failure of equipment, towing, transit, recovery from sea, LSP partly damaged or unable to access LSP	
3	**Engineering and Approvals**		
3.1	Certification/approval by a classification society	Is the HES to be part of a classed system?	
		Identify classification society	
		Check all requirements of issuing authority	
		Submit all relevant details to classing authority	
		Obtain approval from classing authority	
3.2	Materials	Are materials specified in design standard or class standards?	
		Does owner have any specific material requirements?	
		Will environment dictate any materials (hot/cold, etc.)?	
		Are all materials available in the required timescale?	
		Identify any possible alternatives	
3.3	OEM	Can component parts be purchased 'off-shelf'?	
		Has manufacturer/supplier provided such equipment before?	
		Is it suitable for the requirements?	
		Can they provide test results or evidence of previous similar use?	

Item	Point	Notes	Remarks
3.4	Operational input	Discuss detailed proposals with end user	
		Obtain any specific operational input available	
		Get specifications and drawings checked and agreed by operational end users	
4	**Build and Testing**		
4.1	Factory acceptance test	Carry out factory tests of all components/interfaces, etc.	
		Check integration of marine and diving equipment	
		Check interfaces with other parts of HES	
		Document and have witnessed as relevant	
4.2	Classification society	Involve classification surveyor at each stage of manufacture or test	
		Have classification society surveyor witness all tests and critical operations	
		Ensure documentation is correctly stamped by classification surveyor	
4.3	OEM	Obtain from all suppliers/sub-contractors the relevant test, inspection and witnessing documentation	
4.4	Flag	Liaise with flag state authorities at all stages to ensure agreement	
		Notify flag state authorities of any crucial witness points/tests	
4.5	Test – thermal balance	Carry out thermal testing as in IMCA D 02/06 for specified range of external environmental parameters (air/water temperatures) OR other means of compliance such as type approval	
		Document and specify operating limits for external environmental factors	
	Test – environmental control	Carry out 24 hour test as in IMCA D 02/06 to ensure all environmental control equipment functions as intended	
		Monitor environmental parameters during this test	
		Check performance standards are being met	
		Obtain any specific operational input available	
5	**Installation and Commissioning**		
5.1	Verification	Carry out full QA check that all specification and design points have been complied with	
		Carry out full QA check that all certification and supporting documentation are present and correct	
		Check that all operational and maintenance documents are present and correct	
5.2	Test – OEM	Carry out all testing specified by the OEM at time of installation. This should be as identified in a suitable inspection and testing plan	
	Test – flag	Carry out any specific tests required under flag state requirements	
		Invite flag state authorities to witness such tests	
		Obtain agreement from flag state authorities that tests are satisfactory	
		Obtain necessary certification from flag state	

Item	Point	Notes	Remarks
	Test – class	Carry out any specific tests required under classification society requirements	
		Invite classification society to witness such tests	
		Obtain agreement from classification society that tests are satisfactory	
		Obtain necessary certification from classification society	
	Test – functionality	Check ability to connect/disconnect all supplies between HRU and vessel	
		Check ability to mate/un-mate HRU	
		Check ability to launch/recover HRU	
		Check and document flotation, towing and sailing ability trials as relevant	
		Check and document own speed trials if self-propelled	
	Test – LSP	Bring HRU and LSP to same location	
		Check that all LSP connection points fit HRU	
		Connect LSP to HRU	
		Function test all items LSP is meant to provide/control	
		Control HRU from LSP for specified period	
	Test – thermal balance	If required, carry out further thermal testing as specified in IMCA D 02/06	
	Test – HRF	Confirm suitable quayside facilities to receive the HRU	
		Confirm facilities to recover the HRU from water and transport to HRF	
		Confirm facilities to mate the HRU to a decompression facility and transfer the divers	
		Confirm access to specialised medical advice/support	
5.3	As built – data pack	Provide all design information	
		Full set of drawings	
		All material and other certificates	
		Instructions, etc. from all subcontractors and suppliers	
		Properly indexed and filed	
		All class/certification approvals and certificates	
		Provide detailed operations manual for full HES system	
	As built – operational issues	Provide detailed maintenance schedules and instructions	
		Operations manuals for all components	
		Provide detailed specification and schedule for regular test/inspection/certification regime for all components	
5.4	Vessel interface	Check mating facilities and confirm suitable	
		Check that all supply interfaces are correct	
		Ensure that all necessary instructions and equipment are at the launch points	

5 Equipment and Interfaces

Note: The various pieces of equipment forming the overall HES will need to be carefully considered during the planning process as there is an obvious need for items to be compatible with each other, robust enough for their intended purpose, suitable for need, etc.

The paragraphs below are intended to provide a short oversight of this subject.

5.1 Common Interfaces

At the present moment, the layout of HRUs varies considerably, even when supplied by the same manufacturer, and it is impossible to identify common interface points.

Equally it is not practical to suggest modifications to these units in order to comply with any common interface standard as in many cases this would require so much re-engineering that it would result in the unit effectively being re-manufactured.

It is obviously desirable in the long term that all HRUs have common interface points such that an HRU recovered from an evacuation site could be readily mated to virtually any HRF – or possibly even to another saturation diving system.

Towards this end, IMCA has produced common interface recommendations which are fully outlined in document IMCA D 051 – *Hyperbaric evacuation systems (HES) interface recommendations*. It is recommended that all new HRUs built after January 2013 should comply with these interface recommendations.

It needs to be understood that HRUs built prior to this date will not comply (and will possibly be unable to ever be made to) with these interface recommendations. It is expected that owners of such equipment will however carry out an investigation to establish if any of the interfaces are reasonably practical to comply with.

5.2 HRU Specification

This document does not set out specific requirements for the HRU.

The basic requirements for hyperbaric evacuation are included in a variety of places such as IMO Resolution A.692(17), 1991 – *Guidelines and specifications for hyperbaric evacuation systems*, IMCA D 014 – *IMCA International Code of Practice for Offshore Diving*, IMCA D 053 – *IMCA Diving Equipment Systems Inspection Guidance Note (DESIGN) for HES systems* (currently in preparation), OGP Report no. 411 – *Diving Recommended Practice* and in classification society rules, etc.

5.3 Thermal Testing

One of the most important life support parameters for divers living in saturation is the maintenance of correct body core temperature. This is particularly difficult due to the very high thermal conductivity of the helium gas mixture that the divers are breathing.

While it may seem that HRUs require heating to keep the divers warm, experiments have shown that even in relatively cool climates a number of divers close together in an HRU will generate sufficient heat that cooling them is necessary.

For this purpose IMCA commissioned tests that resulted in the publication of information note IMCA D 02/06 plus associated technical guidance note – *The evaluation and testing of the environmental control of hyperbaric systems* – and any HRU will need to be subject to thermal testing relevant to the weather conditions it will operate in as well as the number of likely occupants.

5.4 Life Support Package

The exact detail of the LSP will be dependent on the planning and risk assessment for the method of recovering the HRU and carrying out the decompression. In some circumstances the LSP may be already built in to a specialised recovery vessel and in other cases may be needed only to provide support during transport of the HRU from the recovery site to a nominated HRF.

It is always helpful if a selection of different connectors, etc. is available to deal with local variations and on-site modifications.

The specification below is a recommended minimum for an LSP intended to carry out or complete the full decompression.

Container

- One or more offshore rated container(s);
- If in the same container there should be a dividing wall between control area and machinery;
- Thermal and sound insulation on walls and roof in control area;
- In an area where ambient temperatures are likely to be low there is a need to have heating inside the container. This will provide suitable and stable temperatures for the equipment/machinery and also a suitable working environment for the control area;
- If the ambient temperatures are likely to be high, there is a need to have cooling inside the container. Again, this will provide suitable and stable temperatures for the equipment/machinery and also a suitable working environment for the control area;
- Penetrator panel for incoming/outgoing electrical and other supplies to be sited on opposite side from regular access door;
- Access door to control area which can be opened from both sides;
- Internal lighting with both primary and secondary supply;
- Emergency (battery powered) lighting in all sections;
- Portable external lighting for night working;
- Fire extinguishers or similar;
- Breathing apparatus for operators;
- Low O_2 monitoring in control area.

Electrical Supplies

- Assumed primary power supply by connecting to vessel or shore based main supply. Consideration needs to be made of the possible different operating frequencies;
- This connection to be by isolating transformer;
- Secondary supply required – normally by generator to give self-contained capability;
- Earthing of all components and container is required;
- Required two transformers with variable input and providing outputs of 220/110V ac and 24/12V dc;
- Self-contained emergency lighting should be fitted;
- RCDs fitted wherever possible to protect against electrical failures;
- No specific power requirement stated as this will depend on exact equipment fitted;
- Electrical test certificates required for all parts of installation;
- Electrical supply points inside container to be available for 4 off 110V ac, 1 off 32A 3-phase and 1 off 16A single phase.

Cooling

- The LSP should be able to provide the level of flow and coolant temperature required by the HRU as demonstrated during the thermal balance testing;
- This should also be adequate from the likely environmental parameters to be encountered and the maximum number of divers that could be evacuated;
- There should be 100% redundancy, i.e. two complete cooling systems so that the failure of one does not alter the capability to provide the cooling required.

Heating

- The LSP should be able to provide the level of flow and heating effect required by the HRU as demonstrated during the thermal balance testing;
- This should also be adequate from the likely environmental parameters to be encountered and the minimum number of divers that could be evacuated;
- There should be 100% redundancy, i.e. two complete heating systems so that the failure of one does not alter the capability to provide the heating required.

Control Area

- A control panel similar to that in a normal life support control for a living chamber;
- Ability to continuously monitor depth/CO_2/O_2/temperature;
- Ability to control pressurisation/O_2 injection/BIBS supplies/decompression and gas exhaust/cooling and heating of chamber. This to suit the requirements of the specific HRU in use;
- All gas to be vented external to container;
- Normal level of redundancy as would be found in sat control room on DSV.

Gas Supplies

- Ability to reduce pressure before control panel (normally at quads) if required by the specific HRU;
- Two input supplies of main chamber gas;
- One oxygen supply;
- One BIBS supply;
- Calibration gases.

Consumables

- As the gas mixes and volumes required will be entirely dependent on the depth of the saturated divers, these are guidelines and a list of detailed requirements will need to be prepared for each specific work site. In particular various different mixes may be required for a full decompression;
- A minimum quantity of sodasorb or similar calculated on the basis of a usage of 6Kg of sodasorb per man per day and the length of time anticipated for LSP support.

Note: As it may not be possible for the LSP to contain all of the required consumables for a full decompression, or unforeseen events which may take place, part of the planning should include details of nearby locations which could supply extra consumables, details of the transport requirements to move these to the LSP and a likely timescale for this.

Connection to HRU

- 50m long umbilical;
- Hoses and cable ends to have the correct fittings and plugs to connect to the standard IMCA panel as detailed in IMCA D 051;
- Normally only two water hoses being an inlet and exhaust as these can be used for either hot or cold water;
- Separate hot and cold water hoses (i.e. four in total) can be provided if required.

Supplies to LSP

- Minimum five gas regulators which should all be suitable for oxygen or high oxygen mixes. That is one each for main gas/BIBS mix/O_2 and two spares to be carried in the LSP for fitting to gas quads;
- Five hoses (three for gas and two for O_2, which gives one spare of each type) to connect to the gas quads;
- Minimum length 15 metres (5 metres for oxygen hoses) but risk assessment to consider possible distance to quads if this may be greater;
- Hoses to be ½" diameter with No 8 JIC end fittings;
- Pressure rating of hoses does not need to exceed 200 bar as supply should be regulated at the quad;
- Hoses to be O_2 cleaned as required;
- Hoses to be correct type for the service, i.e. if for O_2, then should be specific O_2 hoses;
- LSP should have a minimum 20m length of main power cable capable of being connected to a supply from shore/ship/generator. Detail of connections will be part of the planning process;
- Sufficient hoses and connectors to connect LSP to water supply. Again this should be part of the planning process and may need to include a submersible pump and filter if water is to be sourced from a harbour or similar.

Communications

- A minimum of four hand-held VHF radios for use by the LSP personnel;
- A mobile phone working on the local system (if applicable);
- A satellite phone (dependant on location);
- A helium unscrambler to talk to divers plus a second one as a spare. These will normally be mains supply with battery back-up;
- A sound powered phone as back up to talk to divers.

Documentation

- A load-out list to check that all components/supplies are present;
- Copies of all relevant manuals including as a minimum, normal and emergency operating procedures, decompression tables and contacts list;
- Copies of relevant certification;
- Tapping code card;
- A quick start guide – typically two pages on how to get the unit running quickly;
- Valve check lists for both LSP control and HRU.

5.5 Hyperbaric Reception Facility

These vary considerably from a simple chamber on standby intended to mate to the HRU to allow decompression of the divers in more comfort and safety using the LSP right through to major national hyperbaric research centres with multiple living chambers.

No detailed specification can be given for the HRF for this reason. However, any HRF needs to meet at least the minimum life support and control requirements laid out above for an LSP.

In addition the HRF needs to meet the following:

- Have the ability to lock in/out medical personnel. This may be by use of a twinlock chamber or by use of a separate TUP chamber;
- Provide facilities for at least 50% of the maximum number of occupants to lie down comfortably;
- Have all facilities required to accept and mate to the HRU;
- Have the ability in terms of life support, toilets, etc. to support the maximum number of occupants without recourse to the HRU which may or may not remain mated to it;

- Have a system in place which will allow the HRU to be lifted in to position by crane but will then support the HRU and control fine alignment/final mating.

Note: A separate DESIGN document, IMCA D 053 – *IMCA DESIGN for HES systems* (currently in preparation), identifies in more detail what is required for the HRF.

5.6 HRU Connection to HRF – Mating Trials

Experience has shown that actual physical mating trials of HRUs to HRFs always provide invaluable information and learning opportunities for those tasked with assembling and operating effective hyperbaric evacuation systems. Desktop assessments alone may fail to identify all the complications and problems which can arise during the HRU to HRF connection phase. Only mating trials can demonstrate conclusively that a particular HRU will readily be able to mate to a specific HRF design. It is therefore recommended that actual mating trials of HRUs to specific HRF designs are carried out rather than desktop assessments alone.

6 Development of Documentation for Hyperbaric Evacuation System Construction and Operation

This section contains a checklist of the various pieces of documentation that require to be considered/produced during every phase of the setting up of an HES. It does this by means of questions or statements of requirement and it is intended that this section will be completed electronically with an explanation or response in each of the **Remarks** boxes on the right hand side (this may be by identifying a supporting document). The completed section will then form part of the documentation used for risk assessment and to provide assurance on the HES.

This section describes each phase in the process and the relevant documentation that may be required:

1. Design;
2. Approval;
3. Construction;
4. Installation;
5. Commissioning and testing (Note: Commissioning and testing has been combined with Installation in this section as this is the most convenient way to assess these activities which are inextricably linked);
6. Operation (Note: This is not included here as it is covered in detail in section 7 on the following pages).

Item	Point	Notes	Remarks
1	**Design of HES**		
1.1	Concept	Identify need – numbers and depth	
		Decide on HRC or SPHL	
		HRC typical on mobile systems used on barges, rigs or vessels of convenience	
		SPHL typical on permanent DSV installation	
		Consider operating environment for thermal balance provision	
		Will it go to HRF or use LSP – or can it do both?	
		Is it able to be launched rapidly?	
		To be used in one location or world-wide?	
		What is the intended duration of on-board support?	
		Will there be a dedicated rescue vessel or local lift off?	
		Are two means of evacuation required?	
1.2	Class	Define/select the classification society to be used	
		The dive system should be classed	
		If it not to be classed, it should be built to classification society rules	
		Intended for a vessel or installation that is classed?	
1.3	IMO/flag state	Is the installation/vessel covered by IMO?	
		Are there any flag state requirements?	
		Does SOLAS apply?	

Item	Point	Notes	Remarks
1.4	Industry guidance	Is any specific industry guidance being used?	
		Does it meet IMCA guidance?	
		Does it comply with other guidance such as OGP/ADCI?	
1.5	Regulations	Which country's regulations apply?	
		Do these regulations have any specific requirements?	
1.6	Functional specification Note: This should include catering for a reasonable level of contingency and should set performance standards	Is it a dedicated HRU or dual function (HRU and living chamber)?	
		If dual function, is the changeover configuration suitable for quick and easy management?	
		Is it to be self-propelled or float away and towed?	
		LSP is to be easy to unpack and use	
		LSP is to be robust and packaged to be easily transportable	
		LSP is to be designed to provide essential life support for a defined period	
		LSP is to have sufficient redundancy for foreseeable breakdowns	
		There should be enough supplies in LSP to be self contained for the defined period, plus spare	
1.7	Specification Note: Specifications should be produced for all components such as SPHL, LSP, HRF, support vessel, etc.	Are there any specific interfaces required – flange dimensions/position; lifting points; external connections/restrictions on LSP?	
		Designed to recognised international standard and a classification society's rules	
		Ability to carry maximum complement of divers in saturation and any necessary support pressure at atmospheric pressure	
		Ability of system (trunking/manways, etc.) to allow transfer of injured diver on a stretcher from dive system in to the chamber	
		Launch and recovery loadings and stresses	
		Depth capability for maximum saturation depth	
		Ability to provide life support for a specified minimum period	
1.8	Maintenance (including marine equipment items)	Design for ease of maintenance	
		Consider access restrictions	
		Provide ability for regular maintenance	
1.9	FMEA/FMECA	Carry out FMEA/FMECA against design specification	
		Carry out HIRA on all HES activities	
		Consider all foreseeable situations including list at launch/likely damage in an emergency/failure of equipment/towing/transit/recovery from sea/LSP partly damaged/unable to access LSP	
2	**Approval/Engineering**		
2.1	Certification/Approval by a classification society	Is the HES to be part of a classed system?	
		Identify classification society	
		Check all requirements of issuing authority	
		Submit all relevant details to classing authority	
		Obtain approval from classing authority	

Item	Point	Notes	Remarks
2.2	Materials	Are materials specified in design standard or class standards?	
		Does owner have any specific material requirements?	
		Will environment dictate any materials (hot/cold, etc.)?	
		Are all materials available in the required timescale?	
		Identify any possible alternatives	
2.3	OEM	Can component parts be purchased 'off-shelf'?	
		Has manufacturer/supplier provided such equipment before?	
		Is it suitable for the requirements?	
		Can they provide test results/evidence of previous similar use?	
2.4	Operational input	Discuss detailed proposals with end user	
		Obtain any specific operational input available	
		Get specifications and drawings checked and agreed by operational end users	
3	**Construction and Build Testing**		
3.1	Factory acceptance test	Carry out factory tests of all components/interfaces, etc.	
		Check integration of marine and diving equipment	
		Check interfaces with other parts of HES	
		Document and have witnessed as relevant	
3.2	Classification society	Involve classification surveyor at each stage of manufacture or test	
		Have classification society surveyor witness all tests and critical operations	
		Ensure documentation is correctly stamped by classification surveyor	
3.3	OEM	Obtain from all suppliers/sub contractors the relevant test/inspection/witnessing documentation	
3.4	Flag	Liaise with flag state authorities at all stages to ensure agreement	
		Notify flag state authorities of any crucial witness points/tests	
3.5	Test – thermal balance	Carry out thermal testing as in IMCA D 02/06 for specified range of external environmental parameters (air/water temperatures) OR other means of compliance such as type approval	
		Document and specify operating limits for external environmental factors	
3.6	Test – environmental control	Carry out 24 hour test as in IMCA D 02/06 to ensure all environmental control equipment functions as intended	
		Monitor environmental parameters during this test	
		Check performance standards are being met	
		Have test witnessed and certified	
4	**Installation/Commissioning/Testing**		
4.1	Verification	Carry out full QA check that all specification/design points have been complied with	
		Carry out full QA check that all certification and supporting documentation is present and correct	
		Check that all operational and maintenance documents are present and correct	
4.2	Test – OEM	Carry out all testing specified by the OEM at time of installation. This should be as identified in a suitable inspection and testing plan	

Item	Point	Notes	Remarks
4.3	Test – flag	Carry out any specific tests required under flag state requirements	
		Invite flag state authorities to witness such tests	
		Obtain agreement from flag state authorities that tests are satisfactory	
		Obtain necessary certification from flag state	
4.4	Test – class	Carry out any specific tests required under classification society requirements	
		Invite classification society to witness such tests	
		Obtain agreement from classification society that tests are satisfactory	
		Obtain necessary certification from classification society	
4.5	Test – functionality	Check ability to connect/disconnect all supplies between HRU and vessel	
		Check ability to mate/un-mate HRU	
		Check ability to launch/recover HRU	
		Check and document flotation/towing/sailing ability trials as relevant	
		Check out and document own speed trials if self-propelled	
4.6	Test – LSP	Bring HRU and LSP in to some location	
		Check that all LSP connection points fit HRU	
		Connect LSP to HRU	
		Function test all items LSP is meant to provide/control	
		Control HRU from LSP for specified period	
4.7	Test – thermal balance	If required, carry out further thermal testing as specified in IMCA D 02/06	
4.8	Test – HRF	Confirm suitable quayside facilities to receive the HRU	
		Confirm facilities to recover the HRU from water and transport to HRF	
		Confirm facilities to mate the HRU to a decompression facility and transfer the divers	
		Confirm access to specialised medical advice/support	
4.9	As built – data pack	Provide all design information	
		Full set of drawings	
		All material and other certificates	
		Instructions etc. from all subcontractors and suppliers	
		Properly indexed and filed	
		All class/certification approvals and certificates	
		Provide detailed operations manual for full HES system	
4.10	As built – operational issues	Provide detailed maintenance schedules and instructions	
		Operations manuals for all components	
		Provide detailed specification and schedule for regular test/inspection/certification regime for all components	
4.11	Vessel interface	Check mating facilities and confirm suitable	
		Check that all supply interfaces are correct	
		Ensure that all necessary instructions and equipment are at the launch points	

7 Elements to be Considered for the Execution of a Hyperbaric Evacuation and Subsequent Decompression

This section contains a checklist of the various matters that need to be considered for the actual execution of a hyperbaric evacuation and subsequent decompression. It does this by means of questions or statements of requirement and it is intended that this section will be completed electronically with an explanation or response in each of the **Remarks** boxes on the right hand side (this may be by identifying a supporting document). The completed section will then form part of the documentation used to risk assess and provide assurance on the HES.

Project Planning, Maintenance and Certification

Item	Point	Guidance Notes	Remarks
1	**Ownership**		
1.1	Marine	Who owns HES equipment? – diving contractor/vessel owner/leased in	
		Who is responsible for equipment?	
1.2	Dive team	Interface/bridging document or emergency procedures	
		List responsibilities	
		Diving contractor responsibilities	
		Team structure prior to launch	
		Maintenance	
		Safe haven for HRU within reasonable distance – consider suitable platform/FPSO/other vessel/landfall	
		Setting up a reception site/safe haven	
		Is there a HRF?	
1.3	Client/owner	Does it comply with IMCA Guidance?	
		Who determines standards and legal requirements?	
		Is equipment classed?	
2	**Verification**		
2.1	Functional verification	Owner driven marine and diving or third party?	
		Build verification – FAT (float test) commissioning	
2.2	Operational verification	PMS – is there one?	
		Launch and recovery testing (annual/six monthly)	
		Mating to HRF and maintenance	
		LSP interface and maintenance	
		Have tests been done (including towing and own speed if relevant)?	
3	**Drills**		
3.1	Various drills	Launch and recovery drill	
		Diver drills/evacuation	
		Injured person to HRC or SPHL (this should include injured diver on stretcher)	
		Split sats or decompressions (i.e. consideration of divers being at different depths in the living chambers and how this will be handled in an evacuation – for example are all blown down to the same level)?	
		LSP support desktop drill – with other vessel or platform	

Item	Point	Guidance Notes	Remarks
		HRF desktop drill – where and how long to get there	
		Craneage and quay facilities	
		Time to recover divers/bell and transfer through to HRU	
3.2	Resources management	People	
		Security, i.e. things being lost or stolen	
		Services such as accommodation for extra people	
		Quay loading (ratings)	
		Media management	
		Craneage – how available?	
		Relatives' reception and management	
		Engineering contingency – what is available?	
		Emergency response drills	
3.3	Authorities	Are third party references correct?	
		Do local authorities need to be informed?	
		Local resources interfaces	
		Nearest embassy	
		Medical assistance	
		Check phone numbers	
4	**Full Launch**		
		Clear, concise nomination of launch team – day for day and night, plus roles and responsibilities (should be in both standard and project specific emergency response and contingency procedures)	
		Consider launch of both SPHLs in a system fitted with two – personnel to launch both/splitting divers between both boats/atmospheric teams to go in both	
		Adequacy of launch instructions at launch point	
		Are these instructions available in all relevant languages?	
		Consider interlocks/gas disconnects/power to equipment (such as power to launch/lighting in launch area	
		Primary/secondary launch systems and backups	
		Pictures for launch (robust enough for anyone)/possibly a training video	
		Similar pictures/video for reception arrangements	
		Launch decision needs to be clearly defined, i.e. who can give the order	
		Consideration given if nominated persons are injured – replacements	
		Consideration if nominated personnel refuse to accept orders, desert posts or do not do what they are supposed to in an emergency – replacements	
		Interface document and bridging document to detail all this	
		RA should be available to all parties	
		Plans to get life support reception team to HRF or LSP site	
		What is available to pull HRC away – other lifeboat/fast rescue boat	

Item	Point	Guidance Notes	Remarks
		People on deck doing launch need a means of escape afterwards	
		All personnel need to be involved	
5	**Familiarisation**		
		Drills	
		Divers	
		Support personnel	
		Familiarisation of all personnel should be logged and critically analysed for adequacy	
		Crew at HRF/LSP need to be familiar with the HRU to be received	
		Abandonment protocol – equipment such GPS, compass and satellite phone plus paperwork, charts and communications lists and directions	
		HRU emergency response procedure should come in format A-B-C-D	
6	**HES Operations Manual**		
		Should include deployment, setting up, operating and demobilising the LSP/HRF	
		Pages should be laminated for use	
		Copies should be kept in: HRU, LSP, HRF reception location, designated emergency response centre and in all vessel control areas such as dive and LS control, bridge, etc.	
		Environmental: air and water temperatures	
7	**Hyperbaric Evacuation (points to consider)**		
		Weather forecasts available to atmospheric crew in SPHL/towing craft	
		Salinity of water (areas such as river deltas may have a large fresh water content meaning that buoyancy and therefore stability/towing, etc. may be altered)	
		Reception site	
		Is HRU an SPHL or HRC	
		Time that HRU can be on its own – 6 hours, 24 hours, 48 hours, etc.	
		Availability and capacity of more than one means of evacuation	
		Towing arrangements/other ships in vicinity	
		Shelter for people who will receive it and for the chamber, i.e. sun or cold	
		Location	
		Transit route including environment, wind and current weather	
		Depth of chamber	
		Safe havens if it is not possible get to designated reception point	
		Communication protocol	
		Communications equipment	
		Water, Sodasorb, food and small equipment	
		Guidance equipment	
		Maps and charts	
		Emergency response plan procedure (generic)	
		Specific local requirement/consumables	
		Designating responsibility for company to detail actionees	

Item	Point	Guidance Notes	Remarks
		Generic/standard company emergency response plan	
8	**Diving (points to consider)**		
		Project specific emergency plan, e.g. bridging document	
		Hyperbaric emergency evacuation	
		Hyperbaric vessel operations manual	
		LSP/HRF operations and maintenance manuals – Note: This should be inserted as a requirement in the new DESIGN audit document	
		Operational and emergency risk assessments for all associated	
		Onshore transportation and logistics support	
		People/resources needs to be determined in plans for onshore support and third party support along with relief personnel for 24 hour cover	
		Guidance on decompression – medical advice and who is authorised to start	
9	**HES Inventory**		
9.1	Documentation	Saturation manual, including decompression tables and logs	
		Emergency procedures	
		Contact lists	
		Machinery manuals and maintenance instructions	
		Anything required by IMO, local regulations or client standards	
9.2	Communications	VHF radio is a firm requirement	
		GPS receiver or similar should be fitted	
		Satellite phones should be considered	
		EPIRB or similar should be fitted	
		Radar reflector is required	
		List of all relevant contacts including diving medical providers	
		Battery chargers	
9.3	Materials	Adequate scrubbing is needed – Sodasorb and other chemicals, pre-packed	
		Light sticks	
		Toolkit suitable	
		Analysers	
		Draeger pumps and tubes	
		Food	
		Drinks – water/isotonic	
		Human metabolic products disposal arrangements	
		Flushing of toilet discharge tanks	
		Emergency fuel	
		Paracord/rope	
		Duct tape and electrical tape	
		If HRU is at sea, then analysis for maximum safe recovery sea state	
		Life jacket and fall arrester consideration for atmospheric crew	

Item	Point	Guidance Notes	Remarks
		Crash hats for both atmospheric crew and occupants	
		Hand and head torches both inside and outside chamber	
		First aid kits and chamber kits	
9.4	Medical	Seasickness medications	
		Medical questionnaire for injured party/doctor interface	
		HRF should meet DMAC 28 and DMAC 15 where possible	
		LSP should meet DMAC 28 and DMAC 15 where possible	
		Consider external monitoring of divers	
		Consider thermal balance and suitability of means of maintaining this	

8 Operational Emergency

This section deals with 'operational emergency' and identifies four distinct phases from the decision to launch the hyperbaric rescue unit (HRU) until the safe decompression of the divers.

These phases are:

Phase A – transfer of the divers into the HRU and make it ready for launch (with a maximum time to undertake this – 15 minutes)

Phase B – the launch of the HRU and for it to be 100 m clear of the vessel/installation being evacuated (with a maximum time to undertake this – 30 minutes. The time starting when the instruction to launch the HRU is given)

Phase C – the transit of the HRU to the reception site

Phase D – safe decompression of the divers

Item	Point	Guidance Notes	Remarks
Phase A (into HRU and ready to launch). Maximum time to complete 15 minutes			
1	**Thermal balance**	Temporary management consideration and awareness (for example, pre-heated or pre-cooled)	
		Equipment pre launch check – survival packs, what do you need?	
		Environmental considerations – ambient air and water temperatures (hot/cold)	
		Atmospheric/cockpit crew cooling or heating	
		Clothing considerations	
		Air conditioning or heating	
		Note: If HRC and in use for routine diving, some of this may not be possible	
2	**Diving muster**	Bell(s) recovered, split sat and decompressing divers to HRU	
		Consideration of divers being at different depths in the living chambers (i.e. split sat and divers in decompression) and how this will be handled in an evacuation – for example, are all blown down to the same level?	
		Topside team as per station bill	
		Competence and familiarity of involved personnel	
		Consideration of technicians, life support personnel, dive supervisors, designated cox – determine who is present	
		Hyperbaric launch notification to all ships in area and nearby assets – clarify who does this and when	
3	**Control/monitoring**	Handover protocol between dive supervisor, atmospheric cockpit team, launch crew, occupants and vessel sat control	
		Procedures need to make clear who is in control at each stage and who can order what	
4	**Deluge**	Cooling prior to launch as required – can deluge system be used for this?	
		May have dedicated deluge system	
		Refer to thermal balance	

Item	Point	Guidance Notes	Remarks
Phase B (launch of HRU and get 100m clear of installation being evacuated). Maximum time to complete 30 minutes – this time starts at point instruction to launch is given HRC being used (SPHL below)			
1	**Hierarchy**	Who is authorised to give the launch instruction?	
		Are there alternatives in case designated personnel have been injured (ref Phase A)	
		Wherever possible have dive supervisor give instructions	
		In dire emergency, the senior person present can make decision	
2	**Launch operation**	On installation launch, the team need to be able to escape themselves	
		Reception team to be transferred to location of LSP by basket or fast boat	
		Communicate to outside vessels and parties that launch is taking place, plus identify any injured personnel under pressure and confirm that it is an HRC	
		Explain to all that no communication will be possible with the HRC occupants other than by tapping code	
		Launch/deploy HRC	
3	**Launch in to sea**	Nominated tow vessel collects towing bridle	
		Tow away from any danger	
		Control speed of tow – not too fast	
		Tow vessel keeps in contact with any other vessels in the area	
		Tow to safe haven such as platform/recovery vessel, etc.	
4	**Launch to deck of another vessel**	Call in reception vessel	
		Lower on to deck	
		Weather conditions may impose severe restraints	
		Secure HRC on deck	
		Reception vessel sails away to safe distance	
		LSP should be on this vessel	
5	**Secondary launch**	If list too great to launch or sinking imminent, release HRC in hope of float off	
Phase B (launch of HRU and get 100m clear of installation being evacuated). Maximum time to complete 30 minutes – this time starts at point instruction to launch is given SPHL being used (HRC above)			
1	**Hierarchy**	Who is authorised to give the launch instruction?	
		Are there alternates in case designated personnel have been injured? (ref Phase A)	
		Wherever possible have dive supervisor give instructions	
		In dire emergency, the senior person present can make decision	
2	**Launch operation**	On installation, the launch team needs to be able to escape themselves	
		Communicate to outside vessels, parties that launch is taking place and identify any injured personnel under pressure and confirm that it is an SPHL. Initiate launch sequence	
3	**Once in sea**	Release falls	
		Cox starts engine/deluge	

Item	Point	Guidance Notes	Remarks
		Sail SPHL away from launch position to safe area (at least 100m away)	
		Atmospheric crew/cox make contact with any other vessels in the area	
		Take no action involving occupants (decompression, etc.)	
		Provide all possible comfort and support to occupants	
		Stop and circle in safe location ready to start Phase C	
4	**Secondary launch**	If list too great to launch or sinking imminent, release SPHL in hope of float off	
Phase C (transit to reception site) HRC being used (SPHL below)			
		Note: If at this point the HRC is on the deck of a rescuing vessel and is securely fastened down with the LSP and the personnel necessary to operate it also on this vessel then that can be considered as the reception site	
1	**If not the reception site**	If on the deck of a vessel but not as above – make for reception site with all speed	
		Consider situation where HRC is on deck but no life support personnel present	
		If HRC is in water and cannot be recovered – tow to the reception site	
Note: The detailed actions in any of the cases above will be dependent on the design and capabilities of the HRC, the part of the world involved, the availability of skilled assistance within a reasonable timescale, weather and other considerations. For this reason it is not possible to consider all possible situations here and detailed planning on a case-by-case basis should have been carried out.			
Phase C (transit to reception site) SPHL being used (HRC above)			
1	**Initial actions (by atmospheric crew)**	Establish what is happening in immediate area, such as other lifeboats, rescue vessels, helicopters, life rafts, etc.	
		Check physical condition of SPHL – any damage and all equipment working	
		Check condition of all occupants – under pressure and atmospheric	
		Try to establish communications with other vessels in the area	
		If possible contact the beach – satellite phone	
		Open up emergency plans, procedures, bridging document and check actions	
2	**Plan to go to safe haven/ reception site**	If possible, obtain weather forecast and check environmental conditions	
		Consider if SPHL can be assisted by a vessel in the area (this may be a previously designated vessel) – lift out water, lash alongside, pull up stern on to deck or obtain tow	
		Evaluate options and agree plan of action – normally this is to get to safe haven as quickly as possible	
		Consider ability to steer SPHL on a correct course in the prevailing conditions	
		Consider ability to navigate correctly to designated safe haven/reception site	
3	**Transit to the reception site**	Consider starting decompression under medical advice. Note: LSS on site has the final decision about this	
		Maintain internal environment of chamber	
		Provide medical treatment to any occupant needing it	
		Consider need to refuel if SPHL running own engine	
		Consider replenishment of consumables, relief personnel, etc.	

Item	Point	Guidance Notes	Remarks
		Consider another vessel (possibly designated for the purpose) accompanying if SPHL sailing under own power and possibly providing a lee for SPHL	
		Obtain navigation or other assistance from others	
		Arrive at the reception site	
PHASE C (Option) NOTE: This section considers the situation where the SPHL has arrived at a safe haven such as a harbour but needs to be taken to a HRF (reception site)			
1	**At the safe haven**	SPHL connect to LSP while still in water	
		Consider lifting SPHL out of water – spreader bar/suitable rigging	
		Identify suitable quay and craneage. Note: This should have been part of the forward planning	
		Take no action until dive support team have arrived	
2	**Transport to HRF**	Ensure suitable cradle/fixing arrangements for SPHL before transport moves	
		Consider the safe operating radius for the SPHL out of water – consider matters such as life support during the journey, cooling, etc.	
		Arrange clear communication between atmospheric occupants and personnel in transport	
		Ability to maintain internal environment until SPHL is fully mated	
		Lift out of water and transit to HRF where specialised personnel will take over	
Phase D (safe decompression) HRC being used (SPHL below)			
NOTE: Once an HRC is at the reception site the LSP will be connected to it and competent personnel will commence decompression under medical advice. Further guidance in this document is therefore not necessary.			
Phase D (safe decompression) SPHL being used (HRC above)			
NOTE: Once the SPHL is at the reception site, it should then be mated with the HRF and the divers transferred to the HRF where decompression will be commenced under medical advice.			

9 Risk Assessment/Hyperbaric Evacuation Plan Guidance

9.1 Introduction

In an emergency, divers in saturation cannot be evacuated by the same methods as other crew members. For all saturation diving operations, a hyperbaric rescue unit (HRU) needs to be provided that, in the event of a vessel or fixed/floating structure evacuation, is capable of evacuating the maximum number of divers that the dive spread is capable of accommodating, to a designated location where the divers can be decompressed in a safe and comfortable manner.

Special arrangements and procedures, which need to be risk assessed, should be in place, to evacuate the divers safely while keeping them under pressure in a purpose built HRU, capable of being removed from the worksite to a safe location while maintaining the divers at the correct pressure and with life support for a minimum of 72 hours (Ref. IMO Resolution A.692(17) – *Guidelines and specifications for hyperbaric evacuation systems*).

The exact design of such equipment and its method of deployment will depend on the facilities available, the number of divers to be evacuated, the location of the worksite, etc. These factors will need to be considered during the risk assessment, which should include the transfer into the HRU, launching, towing/steaming/transportation, recovery and decompression phases of an evacuation.

While in operation, the diving contractor should maintain, in immediate readiness, a contingency room with adequate communications facilities, all relevant documentation and other necessary facilities for the contingency team, in case of an emergency (an example is what is often known as an emergency response centre).

The diving contractor should develop generic emergency training scenarios and procedures to cover every aspect of each activity. Trials should be carried out on all aspects of HES to train personnel and to test the adequacy of the planning, procedures and equipment.

All aspects of the hyperbaric evacuation activities need to have been risk assessed before they can commence. Risk assessments have to be carried out by competent people, with appropriate experience and understanding of the principles behind hyperbaric evacuation.

In addition all hyperbaric evacuation systems fall under IMCA auditing recommendations as detailed in the DESIGN documents. However, the auditing requirement also applies to all the documentation required for the efficient management of hyperbaric evacuations including those listed in management, below.

9.2 Risk Assessment Guidance

The first two parts of this section are an introduction to the basics of risk assessment, giving appropriate information on the principles of the assessment, and examples of the types of criteria that need to be captured as controls to reduce the risks. The final section is a list of examples of the fundamental issues to be captured.

9.2.1 Risk Assessment Basis

The following provides an explanation of the process of risk assessment:

A risk assessment involves identifying the hazards present in any working environment or work activities, and evaluating the extent of the risks involved, taking into account existing precautions and their effectiveness.

a) A hazard is something with the potential to cause harm (this can include articles, substances, equipment, methods of work, the working environment and other aspects of work organisation);

b) A risk is the likelihood of potential harm from that hazard being realised.

The extent of the risk will depend on:

i) The likelihood of that harm occurring;

ii) The potential severity of that harm, i.e. of any resultant injury or adverse health effect; and

iii) *The population which might be affected by the hazard, i.e. the number of people who might be exposed.*

The basic requirements for risk assessments are as follows:

- Initially, identifying all of the activities that will be carried out as part of the hyperbaric evacuation provides the starting point. For each activity the potential hazards, and the hazard effects (the result of the hazard, such as injury, asset damage, fatality), should be identified;
- The fundamental risks can be assessed initially to identify the potential and the severity with limited controls in place, and then followed by identifying the control measures that need to be put in place;
- Following the identification of the mitigating control measures, the potential and severity can be reassessed. Adequate control measures need to be put in place to ensure the lowest possible risk exists. The requirement is to be as low as reasonably practicable (ALARP).

9.2.2 As Low As Reasonably Practicable (ALARP)

The following is an example of explanation of the meaning of the term ALARP.

To carry out an activity with risks as low as reasonably practicable means that the degree of risk should be balanced against the time, cost and physical difficulty of taking measures to avoid the risk. If these are so disproportionate to the risk that it would be unreasonable for the people concerned to have to incur them to prevent it, they are not obliged to do so. The greater the risk, the more reasonable it is to go to very substantial expense, trouble and invention to reduce it.

As the risk being considered in this document is the potential death of a number of divers, the expense and trouble considered reasonable would be very substantial.

9.2.3 Fundamental Requirements

The following list is a summary of the fundamental requirements that should be included in procedures, so that the procedures referred to in control measures for risk assessments generate ALARP controls.

- Management:
  - detailed procedures for operating systems
  - planning and preparations
  - risk assessment
  - injured personnel management;
- Personnel:
  - person in charge
  - manning levels
  - competence
  - roles and responsibilities;
- IMO requirements:
  - SOLAS
  - STCW for coxswain, etc.
  - vessel listing (SOLAS-LSA, 4.4.1.1, Trim 10°, List 20° maximum)
  - launch height (SOLAS-LSA, 4.4.1.7, min 3m survivability, etc.);
- Communications:
  - equipment criteria
  - chain of command
  - function test equipment
  - function test communications;

- Familiarity with:
  - procedures
  - equipment
  - muster lists
  - team requirements
  - medical issues;
- Equipment:
  - minimum requirements as per IMCA recommendations
  - spares (including box of extra bits)
  - tools;
- Lifting arrangements:
  - crane; certification, capacity (man-riding/adequate safety factor), creep potential, minimum hook height, communications/signalling, operator certification, stability
  - HRU compliance with IMCA HES interface recommendations
  - beam (if required); certification, rigidity, centre of gravity preparedness, load capacity, tag lines
  - rigging; certification, sling length (adequate clearance between beam/hook and HRU)
  - lifting of LSP, gas quads, HRF, generator, etc.
  - HRU certification, attachment points;
- Regions of operation:
  - communication language
  - local legal requirements
  - arrangements for communications in local language
  - security/safety (example, security company's armed accompanying vessel for transit)
  - normal weather conditions, atmospheric and water temperature.

9.3 Hyperbaric Evacuation Activities

The following information is a summary of the activities that need to be captured in the hyperbaric risk assessments, with suggestions of aspects that need to be included. The term DSV (dive support vessel) is used for simplicity, but the information should apply to all saturation dive systems wherever they are installed.

Subgroups	Participants	Considerations	Requirements
1 Worksite Hyperbaric Evacuation Drills and Exercises (Excluding Launch)			
a. Dive system internal exercises	Chamber occupants	Access to HRU	Regular drills
		Simulated stretcher exercise	Familiarity
		Survival equipment	
		Medical equipment	
		HRU chamber communications	
		Seating and seatbelt requirements	
		Head gear, etc.	
b. Dive system external exercises	Life support team (sat control)	Actions if key personnel are not available or are injured	Regular drills
	SPHL crew (HRC N/A)	Post drill meetings for recommendations and improvements	Familiarity
	Launch crew		
	Bridge		
	Dive control		
c. Desk top exercise	Key personnel onshore and offshore	Hyperbaric evacuation management	Regular drills Familiarity
2 HRU Launch			
a. Exercise/IMO launch	Life support team (sat control)	Actions if key personnel are not available or are injured	Regular drills
	SPHL crew (HRC N/A)	Unmanned/manned	Familiarity
	Launch crew	Weather conditions	Capture chamber Occupants' names
	Bridge	Location/launch limitations (port/open water)	

Subgroups	Participants	Considerations	Requirements
	Dive control	Equipment damage (HRU flanges, etc.)	
		Failed launch contingency	
		Post drill meetings for recommendations/improvements	
		Hyperbaric lifeboat reliability test (e.g. 30 minutes 'run time')	
		FRC requirements	
b. Emergency evacuation	Life support team (sat control)	Actions if key personnel are not available or are injured	Regular drills Familiarity
	SPHL crew (HRC N/A)	Post drill meetings for recommendations/improvements	
	Launch crew	Weather conditions/sea state	
	Bridge	Cause of emergency	
	Dive control	Bell recovery	
		Vessel listing (SOLAS-LSA, 4.4.1.1, Trim 10°, List 20° maximum)	
		Launch height (SOLAS-LSA, 4.4.1.7, Min 3m survivability, etc.)	
		Crew familiarised/trained (IMO requirement)	
3 HRU Transit			
a. Emergency evacuation	SPHL crew (HRC N/A)	Temperature/climate	Regular drills
		Weather conditions	Familiarity
		Physiological impact	Safe haven/ reception site
		Decompression	Medical advisory service
		Direction limitations: self-propelled/towing capability vessel deck recovery	Potential rescue vessel identification
		Security (e.g. in some areas, such as West Africa, security company support may be a necessity)	

Subgroups	Participants	Considerations	Requirements
		Safe haven	
		Maximum transit radius	
		Speed	
		Gas duration	
		Safe haven/reception site availability	
		Support vessel type/capability	
		Navigation system (HRC N/A)	
		Crew navigation ability (HRC N/A)	
		Communications (sat phone/radio, etc.)	
		Medical support	
		Delay hyperbaric lifeboat departure (rescue vessel arrival within two to three hours)	
4 HRU Speed/Tow Trials			
a. Location	SPHL crew (HRC N/A)	Port, sheltered water or open water	
	Tow vessel crew		
	Bridge		
b. Weather conditions	SPHL crew (HRC N/A)	Limits parameters	
	Tow vessel crew		
	Bridge		
c. Speed recording	SPHL crew (HRC N/A)	Tracking methodology	
	Tow vessel crew		
	Bridge		

Subgroups	Participants	Considerations	Requirements
d. Tow methodology	SPHL crew (HRC N/A)	Vessel	Tow vessel identification
	Tow vessel crew	Speed	
	Bridge	Tow system, e.g. attachments, tow line length, etc.	
e. Manning	SPHL crew (HRC N/A)	Levels	
	Tow vessel crew	Criteria	
f. Support vessel	Support vessel crew	FRC	
		Third party vessel	
5 HRU Hyperbaric Lifeboat Manning			
a. Basic criteria	SPHL crew (HRC N/A)	DSV specific SPHL crew: coxswain/LSS/LST/dive technician or equivalent Crew availability	
b. Qualification requirements	SPHL crew (HRC N/A)	IMO/STCW/IMCA or equivalent	
	Tow vessel crew		
c. Competency training	SPHL crew (HRC N/A)	Industry standard	
	Bridge	Vessel specific	
d. Emergency Scenarios	SPHL crew (HRC N/A)	Inability to man SPHL	
	Bridge	Manning criteria cannot be met (injuries, etc.)	
		Entry prevention (fire/gas/blocked/access/damage, etc.)	
6 HRU Recovery (return to DSV)			
a. Location	SPHL crew (HRC N/A)	Port, sheltered water or open water	Familiarity
	Bridge		
b. Weather conditions	SPHL crew (HRC N/A)	Sea state and wind speed	
	Bridge		

Subgroups	Participants	Considerations	Requirements
c. Contingencies	SPHL crew (HRC N/A)	Inability to recover/mate	
	Bridge	Damage to hull, flange and lift equipment, etc.	
7 HRU Recovery (non DSV)			
a. Location	SPHL crew (HRC N/A)	Quayside/safe haven/platform/rescue vessel	
	Tow vessel crew	Space required	
	Recovery personnel	Site access (transport/equipment, etc.)	
		Local regularity and political requirements	
b. Weather conditions	SPHL crew (HRC N/A)	Sea state/wind	
	Tow vessel crew		
	Recovery personnel		
c. Chamber occupants	SPHL crew (HRC N/A)	Preparedness	
	Tow vessel crew	Stabilisation period requirement	
	Recovery personnel	Injured persons	
	Chamber occupants		
d. Decompression considerations	SPHL crew (HRC N/A)	Commence decompression (before or after recovery)?	Medical advisory service
	Chamber occupants	Decompression rate: standard operating/emergency rate	
e. Crane requirements	SPHL crew (HRC N/A)	Availability, rating, man riding, etc.	
	Recovery personnel		
f. Crane operator	Recovery personnel	Competency, training and experience	
g. Rigging	Recovery personnel	Availability/requirements	
h. Quayside	Recovery personnel	General condition/weight support capacity	
i. Recovery personnel		Competency	

Subgroups	Participants	Considerations	Requirements
j. Reception site	Recovery personnel	Transport to reception site (requirement/availability)	
		Accommodation	
		Preparedness of LSP/HRF	
8 HRU Road Transportation			
a. Transportation	Recovery personnel	Tonnage	
		Truck size	
b. Load support/securing	Recovery personnel	Rigging	
		Materials	
c. LSP	Recovery personnel	Preparedness	
		Mobilise with/without transportation	
d. Gas	Recovery personnel	Availability	
		Volume and %	
e. Journey planning	Recovery personnel	Route	
		Speed/distance	
		Securing/police escort	
d. Reception site		Transport to reception site (requirement/availability)	
		Accommodation	
		Preparedness of LSP/HRF	
9 HRU Road Transfer to LSP/HRF Cradle			
a. Weather conditions	Recovery personnel	Sea state/wind	
	SPHL crew		

Subgroups	Participants	Considerations	Requirements
b. Chamber occupants	SPHL crew	Preparedness	Medical advisory service
		Stabilisation period required	
		Injured persons	
c. Crane	Recovery personnel	Availability, rating, man riding, etc.	
d. Crane operator	Recovery personnel	Competency, training, experience, etc.	
e. Rigging	Recovery personnel	Availability/requirements	
f. Support cradle	Recovery personnel	Site weight support capacity	
		Suitability, rating, etc.	
10 LSP Deployment and Set Up			
a. LSP personnel	LSP personnel	Accommodation/shelter	Local representative
		Supplies (food, water, etc.)	
		PPE	
b. Storage/set up	LSP personnel	Shelter	Local representative
		Supplies (power, food, water, gas, waste disposal, etc.)	
		Injured persons	
c. LSP spares	LSP personnel	Availability	
		Consumables (tools, fittings, etc.)	
		Logs/manuals	
		LSP system certification	
d. Crane	Recovery personnel	Availability/rating, etc.	
		Loading/unloading	
e. HRU access	LSP personnel	Work platform/ladder	
11 LSP Hook Up and Operating Trials			
a. Personnel	LSP personnel	Training	
		PPE	
b. Criteria	LSP personnel	Testing/performance	Local representative
c. Operational requirements	LSP Personnel	Gas connections and flow	

Subgroups	Participants	Considerations	Requirements
		Chiller connections and flow	
		Power connections and flow	
		Thermal control reliability	
		Adequate redundancy	
d. Records	LSP Personnel	Reports	
		Post trials meetings for recommendations/improvements	
12 LSP Operation in an Emergency			
a. Personnel	Recovery personnel	Non evacuated personnel preferred	
		Accommodation/shelter	
		Supplies (food, water, etc.)	
		PPE	
b. HRU	LSP personnel	Condition (damaged/lack of access, etc.) river conditions	
	SPHL crew	Storage depth	
	Recovery personnel	Occupants (condition, cleanliness, food, drink, etc.)	
	Chamber occupants	Decompression	
c. Medical support	Recovery personnel	Availability	Medical advisory service
	Medical advisory service		
13 Portable HRF Deployment and Set Up			
a. Personnel	Recovery personnel	Non evacuated personnel preferred	Familiarity
		Accommodation/shelter	Training
		Supplies (food, water, etc.)	
		PPE	
b. Storage/set up	Portable HRF personnel	Shelter	
	Recovery personnel	Supplies (power, food, water, gas, waste disposal, etc.)	

Subgroups	Participants	Considerations	Requirements
c. Crane	Availability/rating/man riding, etc.		
	Loading/unloading		
d. Portable HRF spares	Portable HRF personnel	Availability	
		Consumables (tools, fittings, etc.)	
		Logs/manuals	
		System certification	
e. HRU cockpit access	Portable HRF personnel	Working platform/ladder	
f. HRU support	Portable HRF personnel	HRU specific cradle	
		Generic cradle/platform	
		Local manufacture/build	
		Flange loading monitoring (Load cells, etc.)	
g. HRU mating	Portable HRF personnel	HRU specific mating flange/spool	
		Local manufacture/build flange/spool	
		Alignment mechanisms (hydraulics/manual, etc.)	
14 HRF/HRU Mating and Operating Trials			
a. HRF		Fixed/portable	
b. Criteria	HRF personnel	Testing/performance	
c. Operational requirements	HRF personnel	Gas connections and flow	
		Chiller connections and flow	
		Power connections and flow	
		Thermal control reliability	
		Adequate redundancy	
d. Records	HRF personnel	Reports	
		Post trials meetings for recommendations/improvements	

Subgroups	Participants	Considerations	Requirements
e. Contingencies	HRF personnel	Asset damage	
		Flange impact (flange protection/control)	
		Flange load monitoring (load cells, etc.)	
15 HRF Operation in an Emergency			
a. Personnel	Recovery personnel	Non evacuated personnel preferred	
	HRF personnel	Accommodation/shelter	
		Supplies (food, water, etc.)	
		PPE	
		Security	
		Transport	
b. HRU	LSP personnel	Condition (damaged, lack of access, etc.) diver conditions	
	SPHL crew	Storage depth	
	Recovery personnel	Occupants (condition, cleanliness, food, drink, etc.)	
	Chamber occupants	Decompression	
c. Mating	HRF personnel	Asset damage	
		Flange impact (flange protection/control)	
		Flange load monitoring (load, cells, etc.)	
d. Medical support	Recovery personnel	Availability	Medical advisory service
	Medical advisory service		
16 Injured Personnel Treatment			
a. IP handling	Chamber occupants	Safe and secure	Medical advisory service
	Recovery personnel	Diagnosis/assessment	

Subgroups	Participants	Considerations	Requirements
		Treatment	
b. First aid	Recovery personnel	Equipment	Qualifications
	Chamber occupants		
c. Medical support	Recovery personnel	Availability	
	Medical advisory service		
17 Decompression			
a. Personnel	Chamber occupants	Safe and secure	Medical advisory service
	Recovery personnel	Preparedness	
		IP treatment	
b. Decompression	Recovery personnel	Start Point (SPHL Launch, transit, safe haven, reception site)	Medical advisory service
	Chamber occupants	Rate (standard decompression rate/emergency decompression rate)	
		Gas availability	
		Accommodation and facilities on arrival at surface for bend watch/final evacuation	
c. Medical support	Recovery personnel	Availability	
	Medical advisory service		
18 Inability to Launch HRU			
a. Personnel	Chamber occupants	Safe and secure	Medical advisory service
	Life support team	Preparedness	
		IP treatment	
b. DSV Condition	Vessel crew	Sinking/afloat	

Subgroups	Participants	Considerations	Requirements
	Chamber occupants	Damaged (fire, collision, etc.)	
		Black ship	
c. HRU condition	Vessel crew	Repairable	
		Time to repair	
		Spares/tools to do the repair	
b. Decompression	Life support team	Sufficient time to reach surface	Medical advisory service
	Chamber occupants	Start point	
		Rate (standard decompression rate/emergency decompression rate)	
		Gas availability	
d. Medical support	Recovery personnel	Availability	Medical advisory service
e. Unable to decompress	Life Support team	Chamber depth to 10msw over bottom depth	
	Chamber occupants	Chamber survival equipment: lung powered scrubbers Survival suit Food and water Warm clothing O_2 and CO_2 Monitors Medical supplies	
		Diving bell(s) (chamber occupants in bell and place on seabed)	Rescue DSV

Example Hazard Identification and Task Risk Assessment (TRA) Worksheet

Task/activity:	SPHL reception trials	TRA No:				Date:	TBC
Vessel/site:	Harbour	Level 1		Level 2		Level 3	
Client/project:	Diving contractor	HIRA meeting		Task risk assessment	✓	TRA/MOC	
Approved by:	TBC	Acknowledgements for legislation/industry guidance/documentation					
Attendees:	TBC						

BASIC SAFETY REQUIREMENTS – (Check (✓) those that apply to the operation)

AFC procedures	✓	7. Permit to work		13. Dive plan		19. MSDS & COSHH	✓	25. Inductions		31. Safety harness	
Isolation – electrical		8. Task Specific training		14. Certification	✓	20. Familiarisation		26. Appropriate PPE	✓	32. Tag lines	✓
Isolation – hydraulic		9. Awareness	✓	15. Communication	✓	21. TRA/TBT	✓	27. 110 volt		33. Barriers/signs	✓
Life jacket	✓	10. Chemical protection		16. Spill Kits	✓	22. Fire watch		28. Competency		34. Supervision	✓
Whip checks	✓	11. Diver briefing		17. DP 2 class vessel		23. ISPS code	✓	29. LOLER compliant	✓	35. Project SMSID	
Tether/umbilical/ downline management		12. Enhanced diving procedures		18. Environmental conditions		24. PUWER compliant	✓	30. Good manual handling techniques	✓	36. Vessel generic TRAs	✓

Activity & Hazard Description			Pre Control Measures Risk Score			Control Measures	Post Control Measures Risk Score			Accountability
Activity	Hazard	Hazard Effect	P	S	R	Preventative and Protective Measures that can be Implemented	P	S	R	Responsibility Of
Lifting Operations (third party) Portable HRF Chamber SPHL and Cradle HRF Control Container	Lifting operations over personnel Lifting equipment failure Loss of control of lifting equipment Third party personnel not competent Incorrect specification of crane supplied Poor environmental conditions – wind Personnel on water's edge	Personal Injury Dropped objects Asset damage – SPHL Company reputation	C	5	H	Task specific briefing held – all personnel involved in task will attend. Competent personnel – party lifting operation Procedures to be followed – third party crane operations, portable HRF operating procedure. Specific lift plans – portable HRF equipment, SPHL and cradle Barrier off lifting area Certification of lifting equipment Pre-use equipment checks conducted Single point of contact controlling lifting operations – banksman Clear communication between banksman and third party crane operation All personnel operating within 1.5 metres of water's edge to be wearing life vests Only essential personnel inside the barrier **Action:** **All Lift plans to be reviewed** **Appropriate personnel to review certificating of lifting equipment** **HRF lifting documentation to be reviewed**	B	5	M	Diving Contractor to nominate

Activity & Hazard Description			Pre Control Measures Risk Score			Control Measures	Post Control Measures Risk Score			Accountability
Activity	**Hazard**	**Hazard Effect**	**P**	**S**	**R**	**Preventative and Protective Measures that can be Implemented**	**P**	**S**	**R**	**Responsibility Of**
Portable HRF chamber mating and disconnection	Incorrect or inability to alignment of mating faces Incorrect flange provided with HRF Inappropriate/inoperable clamp assembly O ring failure Rigging failure Flange impact caused by load movement Pinch points	Asset damage Personnel injury Company reputation	C	5	H	Single point of contact to monitor compliance with third parties procedure & diving contractor requirements Flange protectors to be in situ Competent personnel – riggers, dive technician, diving superintendent, & life support team Sacrificial flange ring installed on SPHL flange SPHL stable in cradle with small controls movements to mate flanges Only essential personnel inside the barrier	B	3	L	Diving contractor to nominate dive tech
Portable HRF chamber trunking leak check	Leaking flange Hose and connection failure Regulator failure	Asset damage Personnel injury	B	2	L	Hose whip checks Competent personnel dive technicians & life support personnel Correctly rated hoses and connections Only essential personnel inside the barrier	B	1	L	Diving contractor to nominate
Launch SPHL	Vessel Specific TRA Not permitted to use quayside ladder	Asset damage Personnel injury				Six monthly drill Competent personnel Familiarisation Personnel transfer On/Off SPHL with FRC ONLY				OPM Master
SPHL recovery	Vessel Specific TRA Not permitted to use quayside ladder	Asset damage Personnel injury				Six monthly drill Competent personnel Familiarisation Personnel transfer On/Off SPHL with FRC ONLY				OPM Master

Example Risk Analysis Matrix

		Severity				
		1. Negligible	**2. Minor**	**3. Moderate**	**4. Serious**	**5. Major**
	Harm to people	First aid case, no health effect	Medical treatment case, slight health effect	Restricted work case, short term health effect	Lost time injury, medium term health effect	Multiple serious injuries, death, long term health effect
	Environmental impact (to water, land or air)	Negligible impact, small spill <1 ltr	Minor impact, spill >1 ltr	Moderate environmental impact	Serious environmental impact (localised)	Major environmental impact (widespread)
	Asset damage (vessel, property, plant/equipment)	Negligible asset damage	Minor asset damage	Moderate asset damage	Serious asset damage	Major asset damage
	Business disruption/reputation (company and client)	No media interest, negligible disruption	Localised media interest, minor disruption	National media interest, moderate disruption	National media coverage, serious disruption	International media coverage, major disruption
	Cost of loss/impact	<£50,000	>£50,000	>£250,000	>£500,000	>£1,000,00
Probability	E. Very likely Almost inevitable an undesired event would result	Medium	Medium	High	High	High
	D. Likely Not certain, additional factors may result in an undesired event	Low	Medium	Medium	High	High
	C. Possible Could happen when additional factors are present	Low	Low	Medium	Medium	High
	B. Unlikely Rare combination of factors required for an undesired event to occur	Low	Low	Low	Medium	Medium
	A. Very unlikely Freak combination of factors required for undesired event to occur	Low	Low	Low	Low	Low

(green)	**Low** Work/activity may continue; risk reducing controls must be maintained	(yellow)	**Medium** Work/activity may continue provided risk control measures identified in the risk assessment are imlemented	(red)	**High** Work/activity must NOT proceed where there is potential harm to people or environmental impact. ALARP must be demonstrated for all other consequences and authorisation to proceed must be given by senior management

10 Personnel and Competence (LSP/HRF)

10.1 Planning

Planning for hyperbaric evacuation needs to take in to consideration all operations and activities where divers are in saturation.

The scenarios to consider are not limited to the reception site or safe haven identified for the work location, as an incident can also occur during transit, port call, weather sheltering or decompression alongside.

In order to ensure that an evacuation can be managed correctly under any of these scenarios, there should be a list of suitable and available personnel maintained by the diving contractor on, for example, a weekly basis.

Emergency response plans should include methods of contacting relevant personnel and the arrangements for transport, etc. to ensure that the appropriate locations have been adequately manned when the HRU arrives.

Although the HRU (particularly if it is an SPHL) will be manned by life support personnel or will have such personnel in close attendance, it should not be assumed that these personnel will be able to continue ensuring the divers are safe and healthy following arrival at the safe location. These life support personnel are likely to have been subject to possibly severe physical and psychological stress and may also be very tired.

These life support personnel can, if they wish, remain in the vicinity so that they can see what is happening, reassure themselves that all is being done for the divers and offer some assistance, but they should not be the primary personnel concerned with the divers' on-going welfare and decompression to surface pressure.

10.2 Personnel Duties and Competence

Note: Where there is an industry recognised qualification scheme, such as for LST and diving supervisor then individuals should, as a minimum, hold these qualifications.

The following is an indicative list of the standard types of personnel that should be available, with a brief summary of their responsibilities:

Life Support Supervisor

A qualified and experienced LST appointed in writing as a supervisor by his company. He is responsible for supervising the set-up of the gasses, their calibration, consumption, and condition. He will supervise the life support technicians for the life support activities and will also maintain contact with the diving doctor if necessary.

Life Support Technicians

Qualified and experienced personnel who carry out appropriate life support activities, including environment management (such as gas mix, ppO_2, $ppCO_2$, temperature, humidity, plus regenerations, communications, hygiene, lavatory use, food and fluids, etc.)

ALSTs/Tenders

These personnel are to assist the life support team, and do not need to be fully qualified as they will always act under the supervision of an LST or LSS. They are to assist in the provision of such as food, fluids, washing facilities, clothes, bedding and laundry. They could be dispatched to supermarkets, restaurants and hotels; wherever the most appropriate support is required.

Diving Technician Supervisor

Responsible for the supervision of the other diving technicians; identifying what needs to be done, overseeing the preparations, set-up, connections, servicing and operating; recording what is done, identifying any problems or breakdowns and ensuring they are rectified as fast as possible.

Diving Technician

Electrical and mechanical technicians who carry out the preparations and set-up for maintenance and repairs, plus assist the life support team in the operation of the equipment.

Senior Diving Contractor Representative

Preferably a superintendent or offshore manager, but can be anyone identified as appropriate and able to take on overall responsibility for all of the hyperbaric reception process. The representative will maintain communications with the duty manager, emergency response team and risk and safety team.

Diving Medical Adviser

If it is appropriate and a suitably experienced diving doctor is available, they can also be at the reception site. As a minimum such a doctor should be contactable by telephone.

10.3 Numbers of Personnel

The following is guidance on the numbers and types of personnel who may be required at various stages of a hyperbaric evacuation. It should be remembered that full decompression may take several days and plans should be in place to ensure that there are sufficient personnel available to allow for normal shift working patterns.

Safe Haven

This is where the HRU arrives on completion of transit. It should be able to commence decompression here or shortly after arrival here. The safe haven can be the reception site, or the point at which the HRU is loaded onto transport and taken to the reception site.

Where the safe haven is will depend on where the incident takes place, and can also be decided as part of the evacuation. As an example, if the vessel is in transit when evacuation is needed, the plan could allow for an LSP to be deployed to a nearby port as fast as possible and that becomes the revised reception site. Also to be considered would be whether it would be safe to transit the HRU to an existing HRF.

If the safe haven is a quay, then this quay needs to be suitable to take the weight of the crane, HRU, cradle, truck, trailer, etc. If the plan is to load the HRU onto a trailer provided by the fixed HRF, then HRF personnel may be able to attend. However, assume that whatever the plan is, the following personnel need to be available:

- diving technician supervisor;
- diving mechanical technician;
- diving electrical technician;
- LSS x 2;
- LST x 2;
- superintendent/designated senior company representative;
- ALST/tender equivalents to support the life support team;
- crane operator, rigger and banksman.

The actual requirements will be identified once the safe haven location and process has been identified.

Reception Site

The reception site is where the HRU will be taken for the safe decompression of the divers to be completed. The site can be the location for the LSP or portable HRF (which system is in place will have been agreed by the client), or a permanent HRF. If it is possible to have additional systems available, then these will probably be solely LSPs. It is also possible that, if a local diving contractor can confirm an LSP is available, they may also be able to provide suitable resources. However, the following are standard requirements:

- diving technician supervisor;

- diving mechanical technician;
- diving electrical technician;
- LSS x 2;
- LST x 2;
- superintendent/designated senior company representative;
- ALST/tender equivalents to support the life support team;
- crane operator, rigger and banksman;
- co-ordinator/logistics representative.

Portable HRF

If the intention is to use a portable HRF to carry out or complete the decompression, then a number of personnel may be required in addition to those identified above. This will depend on which company provides the HRF and whether they require their own personnel to operate the HRF. It will also depend on whether the technicians are familiar with the HRF and its equipment.

SPHL Support Vessel

For any vessel designated to provide support to an SPHL after launch and/or during transit there should be a minimum of one replacement for each of the SPHL crew in addition to any other personnel on the vessel. These personnel should be identified as part of the vessel-specific hyperbaric evacuation procedures and can provide assistance or shift change to the atmospheric personnel who launched with the SPHL.

Fixed HRF

The agreement with the fixed HRF will list the personnel that they will supply, and any additional personnel required from the diving contractor. The availability of the personnel, as mentioned above, should be perfectly capable of meeting any worse case situations for this.

11 Audit and Assurance

There will be two specific parts to any audit of an HES. The first will be an audit of the hardware and equipment involved and the second will be an audit of the documentation provided to demonstrate adequate planning and risk assessment.

Equipment and hardware audit of the HRU, LSP and HRF, plus any other systems involved, should be carried out using IMCA DESIGN document IMCA D 053 – *IMCA DESIGN for HES systems* (currently in preparation). This document sets out minimum levels of equipment and identifies the examination, testing and certification that should have been carried out on this equipment.

Auditing of the documentation involved is more complex as no specific standard document exists to act as a reference. The documents that should be in place and subject to audit should cover the following aspects:

- Identification of resources which will include:
  - a suitable location for the storage and/or reception site within suitable radius of work site
  - reception site agent if available
  - HRU recovery and transportation to the reception site
  - hyperbaric evacuation equipment, technical support and maintenance
  - manning levels throughout the hyperbaric evacuation
  - mobilisation of hyperbaric evacuation personnel
  - travel and accommodation for the HRF/LSP team
  - suitable lifting equipment (crane, forklift, etc.)
  - power supplies
  - water supplies
  - sanitation (for on-site personnel)
  - food supplies (for divers and on-site personnel)
  - availability of support vessels
  - Medical supplies/emergency medical equipment;
- Security aspects such as armed guards and police involvement. There may be a possible need for escort vessels during transit;
- LSP/HRF deployment and set-up procedures;
- LSP/HRF operating procedures;
- Local regulatory and political requirements;
- IMCA/IMO/SOLAS/classification society/flag state requirements;
- Communications detail such as:
  - language to be used during evacuation;
  - notification to vessels in proximity;
  - notification to diving contractor onshore of chamber occupants, including any injuries;
- Risk assessment process, documentation, findings, etc.;
- Documentation provided in HRU, LSP, HRF;
- Bridging document template and detailed contents.

The table on the following page lists examples of some of the matters that should be covered in the project specific hyperbaric evacuation documents:

Table 1: Hyperbaric Evacuation Transit Information

Work Location	Potential Safe Haven/ Reception Site	Safe Haven Lat/Long	Distance Between Location and Site	HRU Max Speed	Minimum Transit Time

Table 2: Safe Haven/Reception Site Emergency Contact Details

Agent		
Crane provider		
Transport provider		
Crane operator/rigging team		
Waste management		
Local medical facilities		

Table 3: Safe Haven/Reception Site Information

Location information		
Can reception site be the same as the safe haven?	Yes/No:	
Security/barriers	Yes/No:	
Suitability for lifting/weights	Yes/No:	
Adequate area available	Yes/No:	
Crane availability	Yes/No:	
Trailer availability	Yes/No:	
Power supply availability	Yes/No:	
Potable water availability	Yes/No:	
Fire mains/salt water availability	Yes/No:	
Fuel supply availability	Yes/No:	
Accommodation in reasonable proximity	Yes/No:	
Food source for all personnel	Yes/No:	
Additional vessel availability contacts	Yes/No	

Table 4: Hyperbaric Evacuation Transit Support

Additional Vessel Availability Contacts		
Coastguard	The Coastguard can pass on information to any other available vessels to provide additional support.	Table 1, above

Acronyms

NOTE: Listed below are the various acronyms used within this document and their meaning. A full glossary of these meanings that are required for a full understanding of this document follows as Appendix 2.

ADCI	Association of Diving Contractors International
ADH	Anti-diuretic hormone
AFC	approved for construction
ALARP	As low as reasonably practicable
ALST	Assistant life support technician
COSHH	Control of Substances Hazardous to Health
DDC	Deck decompression chamber
DESIGN	Diving Equipment and Systems Inspection Guidance Note
DMAC	Diving Medical Advisory Committee
DP	Dynamic positioning
DSV	Diving support vessel
DVT	Deep vein thrombosis
EPIRB	Emergency position indicating radio beacon
F	Fixed
FAT	Factory acceptance test
FMEA	Failure mode effects analysis
FMECA	Failure mode effects and criticality analysis
FPSO	Floating production and storage
FRC	Fast rescue craft
GPS	Global positioning system
HES	Hyperbaric evacuation system
HEU	Hyperbaric evacuation unit
HIRA	Hazard identification and risk assessment
HLB	Hyperbaric life boat
HRC	Hyperbaric rescue chamber
HRF	Hyperbaric reception facility
HRU	Hyperbaric rescue unit
HRV	Hyperbaric rescue vessel
HSE	Health and Safety Executive (UK)
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
ISPS	International Ship & Port Facility Security
LOLER	Lifting Operations & Lifting Equipment Regulations
LSP	Life support package
LSS	Life support supervisor
LST	Life support technician
MOC	Management of change
MSDS	Material safety data sheet
OEM	Original equipment manufacturer
OGP	International Association of Oil & Gas Producers (OGP)
OPM	Offshore project manager
P	Portable
PPE	Personal protective equipment

PSV	Platform supply vessel
PUWER	Provision & Use of Work Equipment Regulations
QA	Quality assurance
STCW	Standards of Training, Certification and Watchkeeping for Seafarers
SMSID	Safety management system interface document
SOLAS	Safety of Life at Sea
SPHL	Self-propelled hyperbaric lifeboat
TBT	Tool box talk
TEMPSC	Totally enclosed motor propelled survival craft
TRA	Task risk assessment
VHF	Very high frequency

Glossary

Note: Where relevant this section also identifies after the word or phrase the relevant acronym used throughout the document.

Diving Medical Adviser
A nominated diving medical specialist appointed by a diving contractor to provide specialist advice.

Fixed (F)
This refers to diving equipment which is installed on a vessel or installation with the intention of remaining in situ long term. It will often be built in below decks or otherwise be installed in such a way that would make it difficult to remove.

Failure Mode Effects Analysis (FMEA)
A formal process for the analysis of potential failure modes within a system including a prediction of the severity and likelihood of each failure. This is normally based on past experience with similar equipment and enables the effect of any failure to be considered and where possible minimised.

Failure Mode Effects and Criticality Analysis (FMECA)
An extended FMEA, which includes a *criticality analysis,* which is used to chart the probability of failure modes against the severity of their consequences. This highlights failure modes with relatively high probability and severity of consequences, allowing remedial effort to be directed where it will produce the greatest value.

Hyperbaric Evacuation System (HES)
This term covers the whole system set up to provide hyperbaric evacuation. It includes the planning, procedures, actual means of evacuation, reception facility, contingency plans, possible safe havens and anything else involved in a successful hyperbaric evacuation.

Hyperbaric Evacuation Unit (HEU)
Another name for the hyperbaric rescue unit.

Hyperbaric Rescue Chamber (HRC)
Normally a pressure vessel adapted to act as a means of hyperbaric evacuation but not fitted inside a conventional lifeboat hull.

Hyperbaric Reception Facility (HRF)
Normally a shore based facility which is capable of accepting a HRC or SPHL and mating it to another chamber such that the evacuated occupants can be transferred in to that chamber and safely decompressed.

Hyperbaric Rescue Unit (HRU)
The term used for the unit used to evacuate the divers away from the saturation system. This may be an HRC or an SPHL or some other pressure vessel.

Life Support Package (LSP)
Note: This may be known by other names such as 'fly-away package'

A collection of equipment and supplies kept in a suitable location such that when the HRC or SPHL arrives at the safe haven it can carry out (or complete) decompression using the LSP components externally to maintain the environment, power, gas mixtures, heating and cooling. This system will take over from or supplement any such equipment or services already mounted on the HRU.

Mobile – also known as portable
This refers to diving equipment which is installed on a vessel or installation on a temporary basis, although this may be for a reasonably long period of time. It will often be situated on an open deck and is installed in such a way that would make it relatively easy to remove to a different location or vessel. It can also refer to such things as LSPs and HRFs set up onshore or at a different location but capable of being moved around.

Original Equipment Manufacturer (OEM)
Equipment which is sold by a company with a specific designated use as a package or unit with a specific designated use. It may be incorporated by a dive system manufacturer or supplier in to a larger package or system.

Planned Maintenance System (PMS)
A management control system which lays out the required frequency and extent of routine maintenance required in order to keep equipment operating at peak efficiency. It normally requires detailed recording of the actions carried out.

Portable – also known as mobile (P)
This refers to diving equipment which is installed on a vessel or installation on a temporary basis, although this may be for a reasonably long period of time. It will often be situated on an open deck and is installed in such a way that would make it relatively easy to remove to a different location or vessel. It can also refer to such things as LSPs and HRFs set up onshore or at a different location but capable of being moved around.

Risk Assessment (RA)
A formal review process which identifies any likely risks involved in a specific operation and considers the likely consequences of each event taking place. It often uses a numerical 'scoring' system to highlight the severity of any one event and is often used to decide if a specific task is considered 'safe' to undertake.

Reception Site
A place where the evacuated divers are in safe environmental conditions and transfer can be made to a decompression facility OR where decompression can be carried out (or completed) in the HRC or SPHL using external life support facilities (LSP).

Typical examples would be:

- a vessel, platform or barge with LSP and life support personnel on board plus the ability to lift the HRC or SPHL onboard;
- full land based HRF with all necessary facilities;
- land based location (quayside, dock, etc.) with LSP and life support personnel present.

Self- Propelled Hyperbaric Lifeboat (SPHL)
Normally a custom designed unit of a pressure vessel contained within a conventional lifeboat hull having equipment to provide suitable life support to the evacuated divers for an extended period. The unit normally has motive power and a small crew at atmospheric pressure to navigate and steer the unit as well as monitoring the divers inside the pressure vessel.
Note: May also be known as hyperbaric lifeboat (HLB) or hyperbaric rescue vessel (HRV).

Safe Haven
A place where the HRU can be taken initially as part of the evacuation plan. It may also be a reception site or it may be an intermediate stop on the way to a reception site.