ATTACHMENT 1
Diver Decontamination Solutions

This attachment of decontamination solutions is not all-inclusive, and other suitable decontamination solutions may be used by the Divemasters with concurrence of the UDO and the Health and Safety Officer. This list is subject to change without notice as new products come to market or further testing is conducted.

The major considerations when choosing a decontamination solution are; 1) effectiveness against the expected site contaminants; 2) compatibility with dry suit materials and other equipment; 3) safety of exposure to both the diver and the tenders; 4) availability and cost; 5) use of biodegradable decontamination solutions or containment and disposal of used non-biodegradable solutions. Decontamination solutions and procedures should be described in the HASP prior to going on-site.

There are numerous decontamination solutions to choose from. Unfortunately, many of the most effective decontamination solutions are very aggressive, corrosive and toxic (LBL 2006). Many disinfectants and sterilants are well suited to cleaning hospital surfaces and equipment, but are not safe to use on divers or some dive equipment. The objective of decontaminating the diver is to remove the contamination from the diver's suit so that the suit can be safely removed. There is no necessity to use solutions that are potentially dangerous to the diver or the equipment when other less dangerous solutions will yield satisfactory results. Removing the contaminants from the diver is more important than neutralizing chemical contaminants or killing biological contaminants. Killing biological contaminants on the divers suit/equipment will usually not be the goal of the initial stage of the decontamination process (while the diver is still dressed), due to the wet contact time required to achieve this. A secondary definitive decontamination of dry suits and equipment may be required after the dry suit/equipment has been removed. Since some of the contaminants at a site may be unknown, it is necessary to use a decontamination solution that is effective for a variety of contaminants (EPA 1985).

Decontamination solutions prepared from concentrated products (e.g., soap or bleach) should be diluted with potable water and not site water, since site water may negatively impact the final strength of the prepared decontamination solution.

It is recommended that prior to the start of site activities the contaminants of concern should be identified and care should be given to select the most appropriate decontamination solution(s). If contaminants are anticipated but not well documented a very conservative approach should be used in selecting the most effective broad based decontamination solution(s). Antimicrobial soap is generally a very effective decontamination solution since it will kill some biological contaminants and is also a surfactant which will remove most contaminants from the diver's suit. When the diver's suit is contaminated with oil and/or grease a decontamination solution with degreasing properties such as Simple Green may be effective as a single decontamination solution or in conjunction with other decontamination solutions. Although an iodine based decontamination solution such as Betadine or alcohol may not be useful as a primary decontamination solution, it may be most effective for use decontaminating various pieces of dive equipment such full face masks (i.e., AGA masks). Harsher or more aggressive decontamination solutions such as tri-sodium phosphate (TSP) and quaternary-ammonium compounds (quats) may not be an ideal primary decontamination solution, but may be useful in performing a secondary definitive decontamination on certain equipment after it has been removed from the diver. Certain commercially available decontamination solutions such as DF200 have been tested and shown to be effective on specific biological and chemical contaminants. Although this solution is more expensive than many of the other decontamination solutions listed below, when those contaminants are present DF200 would likely be the most reliable decontamination solution available.

Water

As noted above, the most important decontamination solution is potable water (EPA, 2010). A plentiful supply of potable water, preferably from a low-pressure hose hooked up to a municipal water supply or a large water tank is the first and last step of all decontamination procedures. If a large tank is not available, smaller containers (e.g., 5-gallon buckets, collapsible plastic containers, Hudson sprayers) of potable water should be available. Water from a hose should not be under pressure any higher than typical municipal water pressure (40 to 70 pounds per square inch). High pressure hoses (e.g., pressure washers) may damage the diver's suit or force contaminants into seams or contaminate nearby surface support personnel. In some instances a thorough rinse with potable water is all the decontamination the diver needs (e.g., after diving in salt water).

Commercial Soaps/Cleaning Solutions

A strong solution of soap/cleaning solutions (dish soap typically has more surfactant than hand soap) is the next most commonly used decontamination solution. Commercial soaps/cleaning solutions are readily available and produced by numerous companies using different various synthetic and/or natural active ingredients. When selecting a soap/cleaning solution the following properties should be considered:

1) Surfactant Effectiveness – The greater the surfactant effectiveness the easier the solution will remove contaminants and oil/grease during the decontamination process. A soap's surfactant action will remove most organic contamination, and scrubbing with soapy water will remove sediment-associated inorganics (e.g., metals). Soap will also wash away biological contaminants (when biological contaminants are washed off, they are not killed, but their physical remove can result in an effective decontamination). When decontaminating oils and grease, the surfactants effectiveness is usually a key consideration when selecting an appropriate decontamination solution.

2) Antimicrobial Properties – Some soap/cleaning solutions include antimicrobial additives. The active ingredient used in most antimicrobial soaps is triclosan. Triclosan works, even at very low concentrations, by blocking enoyl-acyl carrier-protein reductase (ENR), preventing bacteria and fungi from producing fatty acids needed for cell membranes and other vital functions (Senese 2005). Humans don't have the ENR enzyme, and so triclosan is harmless enough for use in a wide variety of consumer goods including cosmetics and toothpaste (Senese 2005). Because of its effectiveness and safety, antimicrobial dish soap is often the solution of choice for decontaminating patients arriving at hospital emergency rooms (USVA 2006; Jagminas 2006). In hand-washing experiments, antimicrobial soap was shown to be more effective at removing biological agents than soap with no antimicrobial additive (CDC 2002).

3) Biodegradability - Many biodegradable products are readily available. When decontamination solutions may be released into the environment during the decontamination process a biodegradable product should be used. When the decontamination solutions are controlled and contained, this criterion is of less importance. The products biodegradability is usually specified on the products label or the associated Material Safety Data Sheet (MSDS).

4) Safety – When selecting an appropriate soap/cleaning solution the safety to the all personnel and equipment should be considered. To access the safety of a solution Material Safety Data Sheet (MSDS) should be consulted. When possible, non-hazardous solutions with a HMIS health rating of 1 or less should be utilized. The MSDS will identify any specific health hazards (eye, skin, ingestion, and inhalation) and the appropriate protective equipment should be used if needed. The MSDS will also list any applicable first aid measures, accidental release measures, handling and storage requirements, exposure controls, and the solutions stability and reactivity (which is important when using multiple decontamination solutions and/or compatibility with dive equipment materials).

Biodegradable antimicrobial soap is a useful decontamination solution because it has wide applicability, ready availability, it is safe for use on both the diver and the diver's suit, and it requires no special PPE or disposal. The leftover soap solution can be used to clean the decontamination zone, the boat or other equipment.

Numerous other safe, effective and biodegradable decontamination soap/cleaning solutions (with or without antimicrobial agents) are available and should be considered based on decontamination requirements. These products include Simple Green® All-Purpose Cleaner (general all purpose cleaner/degreaser), Citrus Klean (natural citrus based cleaner/degreaser), BioSol (Organic solvent degreaser), ZEP Big Orange (natural citrus based cleaner/degreaser), ZEP Acclaim (liquid hand soap), Orange Blossom (natural citrus based cleaner/degreaser) and Citrus Magic (natural citrus based cleaner/degreaser). These products contain various natural and synthetic active ingredients including citrus terpenes [d-Limonene], sodium silicate/metasilicate, linear alcohol ethoxylate, sodium iminodisuccinate, monoethanolamine, dipropylene glycol methyl ether, dipropylene glycol monomethyl, and sodium dodecylbenzene suflonate.

Bleach

Sodium hypochlorite, in the form of chlorine bleach, is a biocide that is readily available in most supermarkets. Household bleach is approximately 6% sodium hypochlorite (Clorox 2005). A 5% solution of bleach (approximately six ounces mixed into a gallon of water) will kill most bacteria, fungi and viruses on a hard, non-porous surface after a five minute contact time (Clorox 2006). In order to overcome the consumption of free chlorine by organic matter in the site water, a 10% solution of bleach (12 ounces in a gallon of water) should be used for diver decontamination. Contact time, in this case, is defined as the length of time the wet solution is in contact with the surface to be cleaned. Contact time should be adjusted to at least ten minutes to adjust for the differences between dive equipment and hard surfaces. It is difficult to keep the diver wet for the entire contact time so bleach is not the best choice to decontaminate the diver's suit. However, it is quite simple and effective to soak the diver's fins, harness, BCD, etc. Care must be taken when using bleach as a decontamination solution, since it will burn eyes and mucous membranes in a 10% solution. Bleach straight from the bottle can burn unprotected skin and can damage clothes and dive equipment. Proper PPE (e.g., disposable rain suits, face shield, surgical gloves) is mandatory when using bleach as a decontamination solution.

Calcium hypochlorite is also used as a biocide, and it is readily available in powder form (e.g., swimming pool chlorine granules). A 10% calcium hypochlorite solution has greater available chlorine than a sodium hypochlorite solution. However, the powder is not readily soluble in water, and should be mixed thoroughly in warm, preferably soft to moderately hard water prior to use. This makes it difficult to achieve a desired concentration. Calcium hypochlorite granules can burn unprotected skin and can damage clothes and dive equipment. The powder also

poses an inhalation risk (Arch Chemicals 2002). Proper PPE (e.g., disposable rain suits, face shield, respirator mask, surgical gloves) is mandatory when using calcium hypochlorite as a decontamination solution.

Betadine

Betadine is a brand name for a 10% povidone-iodine solution commonly used in hospitals to disinfect wounds and prepare skin for surgery. Undiluted Betadine will kill most pathogens after ten minutes of contact time. Contact time, in this case, is defined as the length of time the wet solution is in contact with the surface to be cleaned. The diver must effectively be kept wet with undiluted Betadine for the entire contact time to prevent the solution on the suit from drying. Iodophors such as Betadine use povidone to slow the release of iodine, while using surfactants to increase penetration (Abedon 2003). Since the solution is reddish-brown, it may be easy to see if any areas of the diver's suit have been missed. Care must be taken when using Betadine as a decontamination solution since prolonged contact of large skin areas can lead to excessive absorption of iodine (Purdue 2005). Betadine will also burn eyes and mucous membranes, and will stain clothing, dive equipment, and boats. Proper PPE (e.g., disposable rain suits, face shield/eye protection, gloves) is mandatory when using Betadine, and it is recommended that all surrounding surfaces be covered with disposable plastic sheeting to prevent permanent staining.

Pre-mixed iodine based solutions with a cleaning agent such as Multi-Wash™ Mini have been tested and are commercially available. These types of solutions may not be ideal for primary diver decontamination but are effective in cleaning and disinfecting certain types of dive gear such as full-face masks (Scott Health and Safety 2009).

Quaternary-Ammonium Compounds

Many commercial and household cleaners are based on quaternary-ammonium compounds (quats). These products (e.g., Zepamine A) are designed primarily for deodorizing and sanitizing general household areas, kitchens, cafeterias, food processing equipment/utensils. Additional uses include algae control in pools and cooling systems (Zep 2006). Quats are highly toxic to fish and aquatic plants, and care should be taken not to allow decontamination liquids to enter any body of surface water. If quats are mixed with chlorine bleach, the exothermic reaction is potentially explosive and the resultant chlorine gas may be hazardous. Quats are also corrosive to skin and eyes, and proper PPE and disposal of wash fluid is required.

TSP

TSP is an acronym for tri-sodium phosphate, a strong cleaner/degreaser. However, in the 1970s use of phosphate-containing products was limited. Some products on the market today that are sold as TSP may contain other ingredients and can be less than half TSP (Savogran 2001a). Other products sold as TSP or TSP-substitutes may contain no phosphate and may be acutely corrosive to skin and eyes (Red Devil 2006, Savogran 2001b). TSP products are commonly used to prepare surfaces for painting, remove mildew from home siding, and remove stains from patios or driveways. While TSP is a common household cleaner, it is not appropriate for some materials. TSP will stain metals and can etch glass and fiberglass. When using TSP solutions, care should be taken to cover the surrounding area with plastic sheeting and the decontamination liquids should not be allowed to enter any body of surface water. Proper PPE and disposal of wash fluid is mandatory when using TSP products.

Alcohol

Isopropyl alcohol (IPA) is also a good biocide (NIH 2006), and while it is not appropriate for decontaminating the diver's entire suit and/or equipment, it is ideal for wiping down the areas under the seals of the diver's AGA mask (the latex seal around the diver's face where the mask meets the dry suit), or around the area where the diver's helmet mates to the dry suit. IPA is readily available in supermarkets as a 70% IPA/30% water solution, or as individually packaged wipes. Contact time is immediate. Care should be taken not to get IPA on the diver's face or in the diver's eyes. The readily available 70% IPA solution should not be diluted further before use. Tenders should wear at least eye protection and gloves when working with IPA.

DF200

There have been several recently developed commercial decontamination solutions that have been demonstrated to be effective in neutralizing chemical and biological warfare (CBW) agents. DF-200 is one of these products that have been shown to be very effective against CBW agents while being environmentally safe, work on a wide range of material surfaces and need contact times ranging from about 1 to 30 minutes depending on the organism (DUI 2009).

EasyDECON™ DF200 by Intelagard, a DF200 based decontamination solution distributed by Diving Unlimited International (DUI), was developed as a decontamination solution for use with CBW agents, but it has also been shown to be effective with a select number of toxic industrial chemicals (i.e., organophosphates, chlorine, ammonia, hydrogen cyanide and malathion) and other biological pathogens (*E. coli*, *Salmonella*, *Pfiesteria*, *Giardia*, fungus and molds) (DUI 2009). Although DF200 will neutralize biological contaminants and select chemicals (i.e., organophosphates) it will also act as a surfactant, removing but not neutralizing other chemicals, such as oil/metals etc. Although DF200 may be most effective in some decontamination procedures, unlike many of the other solutions listed, it is not readily available in the field and would be one of the most expensive decontamination solutions evaluated.

Other Decontamination Agents

For crude oil/grease on a dry suit or other dive equipment, a variety of cleaning solutions or wipes impregnated with cleaning agents/degreasers are available. For disinfecting the area under a diver's AGA mask seal or where the helmet mates with the dry suit a variety of individually sealed wipes are readily available (e.g., Saniwipes, benzalkonium chloride wipes, etc.). For chemical and biological agents from terrorism-related incidents, the National Institute of Justice lists other decontamination solutions that may be investigated for suitability (NIJ 2001). Before using any cleaning solvent, its safety for skin contact and compatibility with dry suit and equipment materials must be assessed.

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