THE MYTH OF VULCANIZED RUBBER DRYSUITS FOR CONTAMINATED WATER DIVING

SPECIAL NOTE: The following information is taken from DUI's Exposure Protection for Public Safety Divers Presentation. Diving in contaminated water is a complicated issue and requires specialized training. No diver should attempt diving in contaminated water without this training.

Vulcanized rubber drysuits have been used by public safety divers for many years. There are usually two reasons given for their popularity. One is their relative ease of decontamination. The second is their perceived resistance to permeation by chemical contamination. However with the advent of better methods of decontamination and an increased understanding of the limitations of all materials in chemically contaminated water, other options are now available and are often better suited to the diver's mission and circumstances.

In 1985, the EPA, in conjunction with NOAA, published a landmark report on diving operations in contaminated water. This report stated the best drysuit to use for contaminated water diving is something with a "smooth skin, integrated gloves and hood." While the vulcanized rubber suit is certainly an example of a smooth skin material, they did not specify it was the only possibility. Some trilaminate drysuits are very smooth, and there is also the newer polyurethane suits to consider. This report did not consider the protection of the diver at all nor did it consider that there could be other reasons to use a certain type of material that would override the concern about decontamination. The prime reason for this recommendation was the relative ease of decontaminating a smooth skin suit. The report was very clear in that it also did not say that this was the only material that could be decontaminated – the only thing that was stated was that smooth skin materials are easier.

The report also did not address the other equipment worn by the diver. There was no mention of decontaminating the BCD, regulator hoses, full face masks, etc. All of these products are made of materials that are much more likely to absorb contaminants than many drysuit materials. Even if the diver is wearing a vulcanized rubber suit that is properly decontaminated, cross contamination with the BCD is likely. Also, contamination of the full face mask and hoses should be of higher importance as the diver will be breathing with this equipment.

To this day, there is no detailed standard for diving in contaminated water by any public safety organization in the US including the NFPA. The NFPA is considering forming a committee to establish criteria for equipment selection for diving in contaminated water. This committee would probably not make a recommendation until the end of 2010 at the earliest. In the absence of detailed standards, the best we currently have to work with are the standards used by the Association of Diving Contractors. These standards are also often referred to by OSHA as they do not have standards of their own. As you can see below, they do not have great detail, however, they do reflect the difficulties of establishing detailed standards when exact water analysis is not possible, and the diving conditions and mission can be perpetually changing.

CATEGORY ONE: HIGHEST CONTAMINATION

Grossly contaminated with concentrated chemical or microbiological contamination. Examples include heavy fuel slicks and sewage operations. Divers should use full diving helmets with surface-supplied air and communications, vulcanized rubber suits with integrated helmet mating collar and dry gloves with rings. The helmet should be equipped with at least a double exhaust valve assembly design for use in contaminated water. The helmet must be used in the free-flow mode. This configuration will completely encapsulate the diver as well as be easy to decontaminate.

THIS IS LEVEL A PROTECTION

CATEGORY TWO: MODERATE CONTAMINATION

Increased levels of both chemical and microbiological contamination are expected. Divers may use a positive pressure full-face mask and use it in the positive pressure mode. A block should be used for emergency gas switching to bail out gas in the advent of primary supply failure. A drysuit with a dry hood and gloves for complete encapsulation is required.

THIS IS LEVEL B PROTECTION

CATEGORY THREE: BASELINE CONTAMINATION

No expectation of contamination above baseline that is normal for human habitation. Category Two and Three will be the type of contamination most dive teams and research divers will face during the normal course of events. Divers should wear a positive pressure full-face mask to avoid water contact with mucous membranes and mouth (unless water analysis shows contact with the mouth is an acceptable risk) and thermal protection appropriate for the diving conditions. A body recovery in normally Category Three water will elevate the contamination level in the area of the body to Category Two. A diver should be prepared for an unexpected change in condition.

THIS IS LEVEL C PROTECTION

CATEGORY FOUR: NO CONTAMINATION

This includes situations where no contaminated sources are known or expected such as offshore ocean locations, drinking water reservoirs, recreational areas such as swimming and skiing areas, or areas where water quality is routinely checked and no contaminants are reported. While any type of diving equipment appropriate for the water temperature is acceptable for diver protection, local officials may dictate what the diver may wear in the water so that you do not introduce contaminants. Decontamination may be required before entering the water.

THIS IS LEVEL D PROTECTION

Potable water supplies can have other challenges due to confined spaces and the possibilities of strong water flow. Special training and equipment is often needed.
There are other criteria for selecting an exposure suit. The needs of the dive team will dictate the weight given to each aspect of suit selection. Here are the primary things to consider:

PERMEABILITY

This measures the rate at which a contaminant will penetrate the material of the suit. (Special Note: This is the actual table provided by FEMA. Although the title states it is for the drysuit, seams, seals or zipper, the actual information is ONLY for the drysuit – no information was published on the permeability of the seams, seals or zipper). As you can see in 1987 FEMA Study, Table 26: Summary of Chemical Permeation Resistance Test Results for Selected Contaminated Water Diving Drysuit Materials, different materials will perform differently in different contaminants and at varying concentrations.

TLS material often performs as well or better than vulcanized rubber. As you can see, there are no suit materials that achieved FEMA's goal of lasting for 3 hours in all 5 classes of chemicals**.** No material did well in the hexane and only the neoprene lasted in the toluene (which is the most aggressive hydrocarbon). Of course, neoprene is also the most difficult material to decontaminate. However, all drysuits share a common weakness in that the neck seals, wrist seals, and rubber of the zipper are made from materials that are the least resistant to many chemical contaminants. Also, all of these tests were conducted on new suits. Aging, abrasion, cuts or previous exposures to hazards may deteriorate the performance of the material. There is also no way to know how the suits will react to multiple contaminants or repeated exposures. We also do not know if permeability will be increased at pressure though it is certainly theoretically possible. Given these variables, chemical testing is of dubious value. This is especially true when no one material performs well in all contaminants.

PERMEABILITY

Rate at which a contaminant will permeate the material of the drysuit, seams, seals or zipper

MATERIAL TESTED ASTM 739	Acetone 25% Conc.	Dichloro-Methane 25% Conc.	Hexane 25% Conc.	Sulfuric Acid 25% Conc.	Toluene 25% Conc.
DUI TLS350	>180	76-88 (.48-.56)	4-12 (5.4-13)	120 (.34-1.1)	<4-4 (6.5-15)
Henderson 6mm Neoprene	8-12 (10-20)	8-12 (5.8-7)	<4 (6.5-12)	>180	>180
Viking Pro Vulcanized 1050 g/m^2	60-64 (1.7-2.1)	24-28 (5.7-6.4)	12 (35-140)	>180	12-16 (2.7-8.6)
Viking HD Vulcanized 1500 g/m^2	140-160 (.19-.29)	60-64 (3.3-3.8)	24 (17-72)	>180	28-36 (2.9-3.3)

FEMA Table 26

TENSILE STRENGTH AND PENETRATION RESISTANCE

Both are very important in situations where high wear is expected or the diver is particularly likely to contact sharp metal or other sharp edges. In these types of environments, the ability to decontaminate a suit may be less of an issue than ensuring the diver has a durable puncture resistant barrier. As you can see in the same FEMA study, Table 25 (Comparison of Selected Diving Suit Materials with Recommended Material Performance Requirements) durability is one of the main reasons many dive teams will choose the CF200 drysuit. This study by FEMA was aimed at recommending a suit for swift water use. The CF200 was recommended as the best suit for that situation.

TENSILE STRENGTH AND PRENETRATION RESISTANCE FOR SWIFTWATER

Material	Thermal Insulation	Tensile Strength	Burst Strength	Tear Resist.	Cut Resist.	Puncture Resist.	Snag Resist.
Min. Require.	1.0 Clo	150 lbs.	300 psi	20 lbs	12 lbs	6 lbs	11 lbs
DUI CF200	.271	244-315	300	54.7-65.1	19.5	10.4	212.3-337.6
DUI TLS350	.084	262-310	423	10.5-13.2	10.0	13.2	9.9-11.9
Viking Pro 1050 g/m2	.116	175-226	304	48.1-65.2	12.0	6.8	71.4-86.6
Viking HD 1500 g/m2	.116	182-226	304	75.8	12.0	7.2	91-117.5

FEMA Table 25

ADDITIONAL CRITERIA

Other criteria teams may use to evaluate equipment needs include:

EASE OF DONNING can be an issue for many smaller dive teams. A self-donning suit with the ability to fit a wider range of divers may be very important as it will allow more divers to wear fewer suits and may greatly facilitate entry into the water in an emergency rescue situation.

FIT is often underrated in importance. However, a poor fitting suit can make it difficult for the diver to accomplish the task at hand. Vulcanized rubber suits come in few sizes and are difficult to customize. This is a particular problem for women divers. A baggier suit will make it harder to swim and may make the material more prone to snags.

SWIFT WATER RESCUE usually requires the use of SCUBA due to the high rate of water flow. Drag is also a significant issue. Many dive teams use more streamlined and durable suits such as crushed or compressed neoprene in these situations unless gross contamination is suspected. Other teams will use a lightweight trilaminate because it is light and dries quickly even in very cold air temperatures. All of these suits have excellent swimming characteristics

which is also an important consideration in high-flow situations. The selection depends more on the durability needs of the team and how close fitting they would like the suit to be. As the FEMA report illustrates, the CF200 suit is the most durable. Some other things to consider include:

- Surface suit only: only cuff dumps may be needed for some teams
- Boots for stability in rough water conditions
- Reinforcements in the knees, elbows, and buttocks
- Knife pocket on the suit

ICE RESCUE may involve both surface and diving work. Most rescue situations are surface work and most recovery operations are diving. The trilaminate or vulcanized rubber drysuits are better for very cold environments as they do not freeze in the air. This type of operation requires extensive special training and equipment for diving and surface support personnel.

June 19, 2009