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INTERIM PROTOCOL FOR DIVING OPERATIONS IN CONTAMINATED WATER

by

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16. ABSTRACT

The purpose of this research program and resulting manual have been to improve and update EPA's safety capability which involve underwater hazardous chemical cleanup responses. The manual includes the assessment, testing, evaluation, and demonstration of commercial underwater protective suits, clothing, support equipment, and breathing apparatus in waters contaminated with hazardous substances that may be injurious to a diver's health. The manual also identifies specific types of "in-water" hazards, their location and effects upon divers, their equipment and considerations for protection surface support personnel. The major participates and beneficiaries of this program sponsored by the EPA and NOAA are the U.S. Coast Guard, U.S. Army Corps of Engineers, Department of Energy, Association of Diving Contractors, and the many local underwater search and recovery units.

The helmets which were successfully evaluated for chemical exclusion were the Draeger Helmet System, the Desco "Pot" Diving Hat, Diving Systems International Superlite-17B Helmet, Morse Engineering MK-12 Navy Deep Water Helmet System, and Safety Sea Systems SS-20 Helmax Helmet. Seven different suit configurations were evaluated along with the above stated helmets. One diving dress was from Draeger with the remaining six supplied by Viking Diving Systems.

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SECTION 13

SELECTION OF SPECIFIC SELF-CONTAINED EQUIPMENT AND PROCEDURES FOR BIOLOGICAL HAZARDS

The selection of this self-contained equipment to protect divers from biological hazards was based upon a series of rigorous tests, together with the stipulations that the diver be able to perform work tasks competently and safely in the equipment, and that the gear also be relatively simple and convenient to service, wear, and operate.

Specific controlled tests were run for the Poseidon Unisuit, the Imperial Bubble Suit, the Poseidon Jet Suit, and the Viking Suit. A total of 1,140 recorded dives were made during the NOAA study (4) along with approximately 60 unrecorded dives. Helmets evaluated were the AGA Divator System, the Kirby-Morgan Band Mask, and the Superlite 17.

<u>The AGA Divator Rig</u>. A significant portion of the testing was performed to gain an understanding of how the complete AGA Divator rig would be suited for polluted water diving. The rig is adaptable to a surface supply umbilical, so this aspect also was tested.

The AGA Divator full face mask, as shown in Figure 13.1, is outfitted with a skirt and inner oral nasal manufactured of a special rubber that is soft, rugged, and light-weight, yet impervious to seawater and to extremes of cold and limited chemical concentrations. It has a built-in second stage regulator equipped with a safety pressure device that creates a safety pressure inside the mask. When the safety pressure is turned on by rotating the valve cover toward the diver, a pressure of about one inch of water column over ambient pressure is maintained within the mask. This safety pressure seals a reverse lip at the skirt of the mask, creating a positive and comfortable seal against the facial contours. It also precludes in-leakage and, according to the manufacturer, assures that the mask is self-purging should it become necessary to remove it and put it on underwater. With the safety pressure on, it is nearly impossible to accidentally have the mask removed underwater, making it unlikely that it would ever be knocked off by bumping into an object or by a high current.

The faceplate consists of an extremely wide-angle, high-impact polycarbonate having the same refractive index as water. Peripheral vision is exceptional; however, there is a pronounced "aquarium effect" where the side panels meet the front plate. Some of the masks used during these tests had the side panels roughened up with sandpaper on the inside to eliminate this effect. The mask accommodates wireframed glasses without modification. It has a removable o-ring sealed cover plate for installation of a microphone.

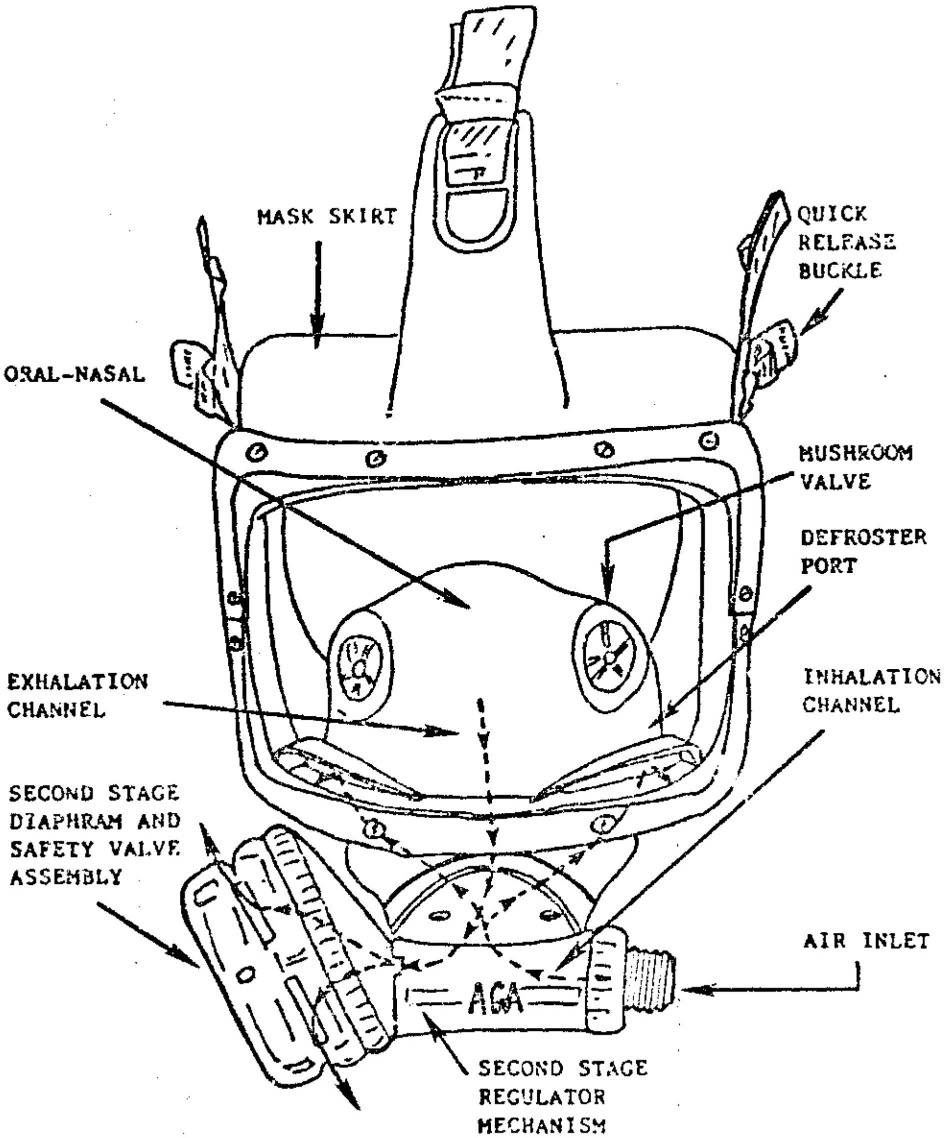


Figure 13.1 AGA Full Face Mask

The AGA Divator also incorporates separate inhalation and exhalation channels to minimize carbon dioxide build-up inside the mask. Inhaled air crosses the faceplate, becoming moisturized as it clears the faceplate, and enters the oral-nasal through mushroom valves. Exhaled air passes directly through the oral-nasal into the exhalation channel, and through a one-way valve into the water. Because of the positive pressure inside the mask, water is unlikely to backflow through the one-way valve. This feature, more than any other, was why the NOAA Report considered the AGA Divator such a good prospect for biologically-polluted water diving use.

SCUBA second stage regulators normally are supplied with air from the first stage regulator at about 140 psi above ambient. The AGA first stage supplies the mask with only 90 psi. This first stage regulator is specifically designed to mount beneath two small inverted air tanks and is not well-suited for mounting on standard SCUBA tanks. Most of the testing, therefore, was accomplished with standard tanks using first stage regulators that had their secondary pressures reduced to 90 psi. The AGA first stage regulator, however, also accommodates a surface-supplied umbilical, so tests were run with the complete AGA Divator rig. In addition to reducing the secondary output pressure of these standard first stage regulators, they were freeze protected. This amounts to filling the pressure-sensing mechanism with silicone fluid and sealing the opening with a flexible rubber cap. In this way the pressure sensing mechanism is isolated from contact with the water, but it can still transmit a pressure signal to the control mechanism. Kits for making this modification usually are supplied by the regulator manufacturer.

There is a pressure sensing mechanism inside the AGA Divator first stage regulator that will keep the diver breathing umbilical air so long as it is supplied at a pressure greater than 90 psi. As discussed in the previous section, however, pressure greater than 110 psi will break the pressure-balancing diaphragm inside the second stage mechanism. When the umbilical pressure drops below 90 psi, the regulator automatically switches to the tanks, and the diver does not know this is happening. During field tests in this mode, occasionally a diver found his tank pressure much lower than it should have been when he switched to his tanks. The reason was traced to this phenomenon. To prevent this during the tests, the AGA tanks were secured by the diver until he actually needed them. This turned out to be practical and easy to do.

During early dives with the complete AGA Divator rig, divers found they were excessively heavy. It was determined that when the AGA tanks are filled with air they are 19 pounds negative in fresh water. This implies that a wet-suited diver needs no extra weight when diving with this rig, and a dry-suited diver can use 19 pounds less than he normally would use. This results in an extremely comfortable dive, especially when diving in a non-neoprene suit.

During an evaluation dive, the diver descended on surface supply and at depth he switched from umbilical to tanks. Very shortly thereafter he experienced heavy breathing resistance. He commenced immediate ascent to the surface. By the time he had reached the surface, he could get no air at all from the mask, yet his tank gauge showed nearly 4,000 psi in the tanks. In the field this could have been a potentially disasterous problem, although it was easily handled under the controlled circumstances of the in-depth study.

A detailed look at this problem determined that water from a previous dive which had found its way inside the AGA first stage regulator had not been completely removed by the five minutes of free-flow. It had penetrated around the main valve spring where it was isolated from umbilical air flowing through the regulator. When the diver disconnected his umbilical and switched to his tanks, water around the main spring was distributed throughout the regulator by the high-pressure tank air flowing past the spring. The adiabatic pressure change dropped the regulator body temperature below freezing, and the entire regulator became clogged with ice.

This seems to be a design defect of the AGA Divator first stage regulator, since there appears to be no way to get water away from the main spring without using tank air which immediately freezes up the regulator. This problem effectively precludes its use for combined surface-supply and SCUBA operations except under carefully controlled circumstances where there is absolutely no chance of water getting into the first stage.

AGA Divator and dry suit compatibility. The AGA Divator seats against the face with a broad, turned inward skirt. The internal safety pressure assists in making the seal. Dives were made with the mask seal against the face and the hood seal against the mask, and the other way round. Some face seals had been modified so that they made a good seal with the outer side of the AGA Divator mask. Some of the face seals were designed with a smooth rubber surface facing out so that the mask could make a good seal against it. Thus, the two basic configurations were mask outside of hood, and hood outside of mask.

The AGA Divator conformed well to most facial contours and so generally made a good seal against the face. In cases where the diver's facial contours or his facial hair interfered with a complete seal, air leaked out from around the mask. With the hood outside the mask, the hood filled with air. For divers experiencing this problem, it was found that the hood made a better seal against the face than the mask did . These divers were more satisfied with the mask against the outside of the hood seal. In cases where the hood seal outer surface was nylon, there was a continual stream of air leaking from around the mask. Where the hood seal outer surface was smooth rubber, the mask made an effective seal against the hood and there was no leakage of air.

Future suits should be obtained with a smooth rubber outer surface on the face seal, and the mask normally should be worn against this surface.

The AGA Divator mask can be made compatible with all types of dry suit hoods. The ideal arrangement, however, is a hood face seal with a smooth rubber outer surface against which the mask seals.

The summary of the AGA Divator evaluation and testing is as follows:

1. Any first stage regulator from the top list in the Navy Experimental Diving Group regulator study (Middleton, 1980) can be used to supply the AGA Divator mask. Care must be taken to ensure that the regulator, adaptor fitting (if any), and hose are compatible. The regulator must have its secondary output pressure reduced to 90 psi, and the pressure sensing mechanism must be freeze-protected.

2. The complete AGA Divator rig, including mask, first stage regulator, tanks, and backpack, is compatible for polluted water diving, but there are certain drawbacks. The unit cannot be used in the combined surface supply-SCUBA mode without very special precautions. The suit air supply must be thought out in advance, and care must be exercised to ensure that fittings are compatible. An appropriate charging source for the tanks also must be available for full utilization of the rig.

3. A flooded AGA Divator mask will dewater itself automatically if proper procedures are used; however, the diver should be trained and practiced in these procedures. It is unlikely that the mask will become dislodged or knocked off accidentally.

4. The AGA Divator mask can be made compatible with all types of dry suit hoods. The ideal arrangement, however, is a hood face seal with a smooth rubber outer surface against which the mask can seal.

5. When used with an AGA Divator, snug-type dry suits consume about one-third less air than do bulky-type suits. Bulky-type non-neoprene suits consume about one-third more air than do bulky-type neoprene suits.

The Kirby-Morgan Band Mask

The lightweight diving outfit is surface-supplied with air for breathing, but unlike the deep-sea outfit, it does not admit air into the diving dress for buoyancy control. Diving which uses lightweight equipment is limited in depth, depending upon the equipment being used.

If the KM Band Mask or USN MK 1 shown in Fig. 13.2 is used, depths are limited to 130 feet (39.6 meters) without the support of an open bell and 190 feet (57.9 meters) with a bell. The basic components of a lightweight outfit are:

The mask group which includes all valving. There are two different models of lightweight masks--the standard or "Jack Browne" rig, which is not suitable for polluted water operations, or the KMB Mask and USN MK 1.

The diving dress group, which includes the diving dress (with two styles, wet or dry, available), and gloves, shoes, chafing pants, weighted belt, and knife.

The hose group, which includes the air hose and fittings, lifeline, communications cable (if applicable) and the pneumofathometer.

Figure 13.2 Pathogenically Protected Diver with Heavy Duty Viking Dry Suit and Surface Supplied Kirby Morgan Band Mask

The Band Mask is an improved version of the standard lightweight mask. It permits two-way voice communication between the diver and the surface, and it has features that minimize the dangers of flooding, face squeeze, and CO_2 buildup. The mask is basically a demand breathing apparatus, but incorporates an emergency free flow capability for defogging the faceplate. This free flow may also be used as an emergency breathing mode or for clearing the mask when flooded. The demand regulator is manually adjusted during a dive to accommodate changing overbottom pressures supplied to the mask. It can be adjusted to provide continuous flow through the oral-nasal mask should a specific operational dive scenario require this. The mask, however, is basically a demand mask and provides all the air required by the diver when used in the demand mode; the above "dial-a-breath" and emergency free flow are not routinely utilized. For added safety beyond 60-foot depth usage, the mask is equipped with a backup air supply bottle commonly referred to as a "come home bottle," or "pony bottle."

The band mask is built around a molded plastic frame upon which are mounted a rubber face seal, a head harness, a faceplate lens made of 1/4-inch acrylic plastic, a side block assembly, a demand regulator and a moveable nose pad, which can be used by the diver as an aid in clearing his ears and sinuses.

-- Side Block Assembly -- This assembly functions as a manifold. It is fitted with an on/off defogger valve, which controls a steady air flow into the mask and across the inside of the faceplate. This feature is also used as an emergency breathing mode in the event of demand regulator failure. The emergency breathing supply valve for the come home bottle is located on the rear of the side block. The non-return valve is located within the side block assembly.

-- Demand Regulator -- The demand regulator is set into the mask in front of the diver's mouth. This regulator is similar to the second stage of a single hose SCUBA regulator. Air passes to the demand regulator from the side block assembly through a hard pipe; the flow of air is controlled by the diver's breathing rate. A manual purge button permits the diver to establish a free flow through the regulator. The regulator is adjusted by a knob on its side to accommodate air supplied at overbottom pressures as necessitated by operational requirements. The knob can be opened slightly to permit a free flow through the oral-nasal mask as discussed previously.

-- Emergency Air Supply -- The emergency breathing supply valve provides an air supply path parallel to the non-return valve. Threads on the inlet of this valve permit attachment of the "come home bottle" whip. The "come home bottle" is equipped with a SCUBA type first stage regulator.

-- Frame Exhaust Valve -- This is a mushroom-type valve which is located in the mask frame under the demand regulator. The exhaust valve is at the lowest point in the mask; therefore, when the mask is upright, the discharge through the valve automatically purges water from the mask. Under ordinary conditions, this valve accommodates the steady defogger flow.

-- Oral-Nasal Mask -- This unit is mounted inside the main body of the mask, an arrangement which reduces both dead space within the mask and the potential for CO_2 build-up. In normal demand operation, the air flows directly into the oral-nasal mask and is directed through the regulator exhaust. When emergency free flow, defogging, or venting is executed by opening the defogger valve, part of the flow enters the oral-nasal mask through a check valve in its wall and passes out through the regulator exhaust valve. The oral-nasal mask is a vital component of the MK 1 mask and must never be removed.

-- Communications -- Earphone and microphone assemblies are installed in the mask. Communication wires pass through a watertight fitting in the mask frame and are appropriately connected to internal terminal posts. Standard Navy amplifiers are compatible with this equipment.

The diving dress which has been utilized with the band mask includes the Unisuit, Viking Dry Suit, and standard wet suit.

A summary of the band mask test evaluations is as follows:

1. Demand mode, normally used for band mask operations, cannot be used for polluted water diving.

2. Open circuit mode is effective for polluted water diving, but only should be used with surface supply because of high air consumption.

3. Both Mod 1 and Mod 2, when coupled to a polluted water-modified hood, can be used for polluted water diving in either SCUBA or surface-supply mode.

Modification one (Mod 1) consisted of placing U.S. Divers' exhalation flutter valves over the exhaust tee ends to prevent backflow of water into the second stage regulator attached to the mask. The standard hood, which has a slide fastener from the top of the head down the back for ease of entry, was replaced with a hood minus the slide fastener. This was designed specifically for ease of mating to the neck seal using Viking neck clamps. Mod 1 was intended for SCUBA use in demand mode only except for occasional use of the defogger valve to clear the faceplate. During surface-supplied tests, both demand and open circuit were used.

Modification two (Mod 2) consisted of removing the second stage exhaust valve entirely, blanking off the opening, and reversing the mushroom valve through the oral-nasal so that air flow was from the oral-nasal to the mask instead of the other way around. In this configuration, breathing air could be obtained only through the demand valve. Air from the defogger valve could be used to clear the faceplate, but was not available for breathing. Hood modifications were identical to those for Mod 1.

The band mask is supplied from a first stage regulator just as standard SCUBA regulators are. The first stage regulator must be freeze protected as with the AGA Divator. During these tests, the U.S. Divers Conshelf and the Scubapro Mark 5 were used, but it must be remembered that the Mark 5 is difficult to freeze protect. The test dives were in clean water, so freeze protection was not critical, and the available supply of freeze protected first stage regulators was augmented by the MARK 5 regulators present.

During normal use, most divers put a small hole in the top of their dry suit and band mask hoods. While diving, air often escapes around the neck seal or face seal and accumulates in the hood. This hole serves to let that air out. This hole also lets water in, so this practice is unacceptable for diving in contaminated water. A provisional solution to this problem was found during the field studies. A Sea Quest BC overpressurization valve was installed in the hoods. The valve was fitted with the lightest spring available from Sea Quest, but when this proved to be too stiff, it was further reduced by clipping off various lengths until an apparently satisfactory size was found. BC overpressurization valves adjusted in this fashion were installed in all suit and band mask hoods.

4. When the modified hood is mated to a dry suit, care must be taken to ensure that the whole arrangement is not too tight. Removal of thick neoprene hoods from the dry suit, leaving enough material to mate with the band mask hood, appears to be the best solution where thick hoods cause excessive tightness.

5. Effective hood relief valve cracking pressure experimentally is less than 0.2 psi. The position of the spring within valve housing, or the valve housing used, is not a significant factor. Relief valve findings are sketchy, however, and more work is needed before further definitive statements can be made.

Recommended Diving Dress for Microbiological Hazards

The recommended system presented here is not the only solution to the problem of protecting a SCUBA diver from the hazards of polluted water. It certainly is not the best solution, for gaps still exist, and research still goes forward; but it is a working solution, one that the findings of this study clearly show adequately protects the SCUBA diver. It can be considered an interim solution for biologically-contaminated water, one that can be, and already is being used around the world where standard SCUBA techniques are inadequate, and where surface supply cannot be used.

One of the basic premises of this undertaking was that the final solution had to include equipment that was available off-the-shelf with little or no modification required to make it functional for use in contaminated water. Also, it had to be reasonably priced, simple in design, and easy to use.

There were two elements specifically required, a suit and a mask. The research turned up a generalized suit solution, and two mask solutions, one generalized, and the other brand specific, the preferred solution being the latter. Williscraft (15) went to great lengths to avoid specific brand endorsement or disparagement during this study, and the inclusion of a specific mask in the recommended solution should not be considered as an endorsement of the manufacturer's product; rather, it should be considered as an endorsement of the underlying principles the manufacturer chose to apply in the production of this particular mask. Any future mask appearing on the market which would possess similar characteristics would be equally acceptable after a suitable series of tests to ensure that it did not compromise the essential requirement--absolute exclusion of the outside environment.

The suit. The recommended suit is a "smooth skin" dry suit having the following characteristics: It must have an attached hood and attached boots, although the hood may be removable so long as it can be mated to the suit with a waterproof seal as in the Viking Suit. It must have a means of inflation from either the diver's air tanks or from an external "pony bottle." Care must be taken to ensure that any adaptors used in the inflation hose are flow matched to the hose. It must have a diver-controllable exhaust valve that keeps water out of the suit. The hood must have an installed relief valve that relieves automatically to vent off any air accumulating in the hood. And above all, the suit must keep the diver completely dry on a test dive in clean water.

A diver requiring hand protection can add special cuffs to his dry suit and attach heavy-duty rubber gloves with long cuffs to these suit cuffs. Attachment can be accomplished by slipping a short piece of plastic pipe over hand and wrist, and clamping the glove and suit cuff to this pipe section with a hose clamp. Care should be taken to ensure that the seams where the cuffs attach to the suit are genuinely waterproof.

The mask. The recommended mask is the AGA Divator mask coupled to any standard first stage regulator noted in the top listing of the Navy Experimental Diving Group regulator study (Middleton, 1980). This first stage regulator must have its secondary output pressure reduced to 90 psi, and it must be freeze-protected. Since the AGA Divator is manufactured to metric standards, and most of the first stage regulators on the Navy list are manufactured to U.S. standards, it may be necessary to use adaptors to connect the two items. Where possible, the AGA Divator hose should have its metric fittings removed and an appropriate fitting attached. Otherwise, care must be taken to ensure that the adaptors are flow matched to the hose. In use, the mask safety pressure must always be turned on.

The complete AGA Divator rig also is acceptable, provided appropriate means are used to supply air for suit inflation. This complete outfit, however, is quite expensive, especially when one considers the required ancillary equipment, so this solution does not really meet the originally-stipulated cost requirements.

It is possible that other manufacturers will choose to produce masks that, like the Divator, are internally pressurized to prevent in-leakage of water. When produced, such masks also will be acceptable provided in-leakage is absolutely prevented. A particular point to watch out for is back-seepage around the exhaust diaphragm. In the Divator, this problem is circumvented by separating the inhalation and exhalation channels. Any new mask must solve this problem with equal success.

The other recommended mask solution is a band mask, Mod 1 or Mod 2. Mod 1 consists of attaching flutter valves to both sides of the mask exhaust tee. Mod 2 consists of removing the second stage regulator exhaust diaphragm and housing, blanking off the opening, and reversing the mushroom valve in the oral-nasal. For both modifications, the hood is replaced with one having no slide fastener and having a straight neck designed for attachment to the suit neck with a ring and clamp similar to the Viking Suit ring and clamp. The hood also must have a relief valve near the top set to release at no more than 0.2 psi.

The band mask is not the solution of choice, because, like the complete AGA Divator rig, it is quite expensive and, therefore, outside the originally stipulated cost requirements. Many diving organizations, however, already possess one or more such masks, and in this case, this solution is much less expensive than any other. It must be stressed that diver comfort is lower than with the AGA Divator, and the band mask configured for polluted water diving is more cumbersome to put on and take off. Diver abandonment of his breathing equipment underwater also is much more difficult with this equipment, but this action always should be considered as the very last resort in polluted water.

A final consideration when using a modified band mask for polluted water diving is that it may be necessary to remove neoprene dry suit hoods in order to make the rig sufficiently comfortable. Should this be done, enough suit hood material must be left to allow for mating of the band mask hood to the dry suit.

SECTION 24

DECONTAMINATION PROCEDURES

As part of the system to prevent or reduce the physical transfer of contaminants by people and/or equipment from on-site, procedures must be instituted for decontaminating anything leaving the Exclusion Area and Contamination Reduction Area. These procedures include the decontamination of personnel, protective equipment, monitoring equipment, clean-up equipment, etc. Unless otherwise demonstrated, everything leaving the Exclusion Area should be considered contaminated and appropriate methods established for decontamination.

In general, decontamination at the site consists of rinsing equipment, personnel, etc., with copious amounts of water and washing same with a detergent/water solution. If contaminants are known, then a specific detergent and/or solvent can be used to decontaminate. Fig. 24.1 illustrates the maximum physical layout for personnel decontamination during a worst case situation. Fig. 24.2 illustrates the minimum physical layout for personnel decontamination for a relatively small well-identified situation. Each site requires special consideration and the decontamination procedures should be modified from the maximum to minimum layout based on known information.

Decontamination (Decon) and Rinse Solutions

The decon solutions should be solutions of water and chemical compounds designed to react with and neutralize the specific contaminants. The temperature and contact time also should be considered in order to insure complete neutralization. An excellent unit for applying decon and surfactant solutions is a La-Pressure Washer, Model 914. The washer delivers 4 GPM at 1000 psi and can withdraw decon solutions via a siphon feed hose.

The contaminants will not always be known in a majority of cases and it will be necessary to use a decon solution that is effective for a variety of contaminants. Two of these general decon solutions are listed below:

- o <u>Decon Solution A</u> - A solution containing 5% Sodium Carbonate (Na_2CO_3) and 5% Trisodium Phosphate (Na_3PO_4). Mix four (4) pounds of commercial grade Na_2CO_3 plus four (4) pounds commercial grade Na_3PO_4 with each ten (10) gallons of water. These chemicals are available at most hardware stores.

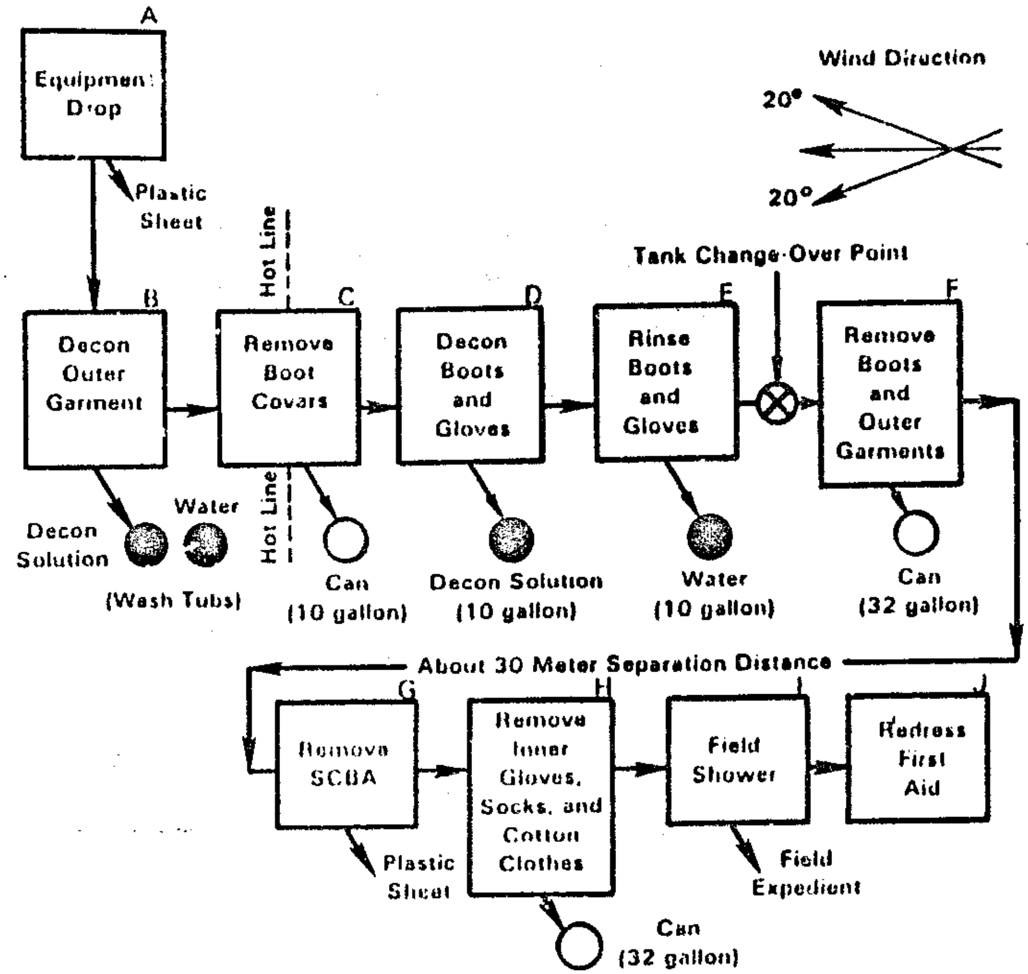


Figure 24.1 Maximum layout of personnel decontamination station. (Levels A & B Protection)

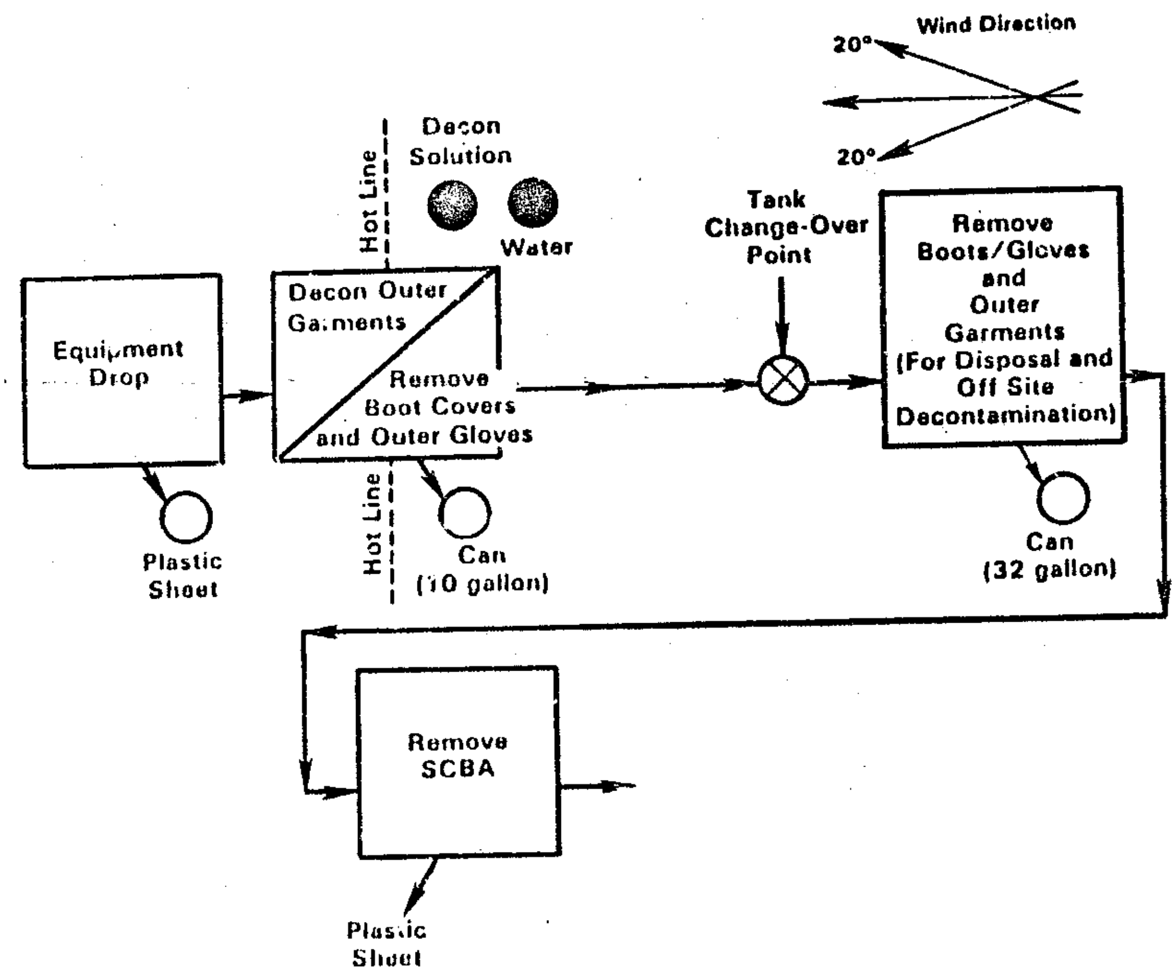


Figure 24.2 Minimum layout of the PDS.
(Level A, B & C Protection)

o **Decon Solution B** - A solution containing 10% Calcium Hypochlorite ($Ca(ClO)_2$). Mix eight (8) pounds of $Ca(ClO)_2$ with each ten (10) gallons of water. Calcium Hypochlorite (HTH) is available at most hardware or pool supply stores.

The rinse solutions used in decon should have the ability not only to remove the decon solution physically, but also to neutralize excess decon solution.

A general purpose rinse solution, used for both decon solutions listed above consists of a five (5) percent solution of Trisodium Phosphate. Mix four (4) pounds Na_3PO_4 with each ten (10) gallons of water.

A final rinse of liquid Ivory soap solution is recommended on all decon procedures followed by fresh water. (See Figures 24.3 and 24.4)

Operational Considerations

The decontamination procedures illustrated in Fig. 24.1 are for Level A protection which more often than not requires a detailed decontamination process during a worst case situation (i.e., Dioxin contamination, chemical fire, immediately dangerous to life or health atmospheres). Fig. 24.2 illustrates the minimum physical layout for personnel decontamination during a relatively small, well-defined situation (i.e., pesticide spill, solvent spill, etc.).

Less extensive procedures for decontamination can be subsequently or initially established when the type and degree of contamination through analysis becomes known or the potential for transfer is judged to be minimum. These procedures generally involve one or two washdowns only, and fewer precautionary measures in doffing equipment. These procedures would not involve additional decontamination of the protective clothing which is removed. Table 24.1 lists general decon solutions and their applications.

In extreme situations when there may be a question of the efficacy of decontamination to known or strongly suspect substances of a highly toxic nature, protective clothing may have to be discarded after use or tested after decontamination.

Consideration must also be given to the protective equipment worn by those personnel operating the decontamination line. In most cases, chemical protective clothing, boots, and gloves should suffice. Unless it is suspected and/or confirmed that personnel needing decontamination are highly contaminated, air-purifying respirators with suitable canisters can be worn (Level C Protection).

Decontamination solutions should be designed to react with and neutralize the specific potential contaminants involved in an incident. However, since the contaminants at an uncontrolled waste site will be unknown in the majority of cases, it is necessary to use a decontamination solution that is effective for a variety of contaminants. Several of these

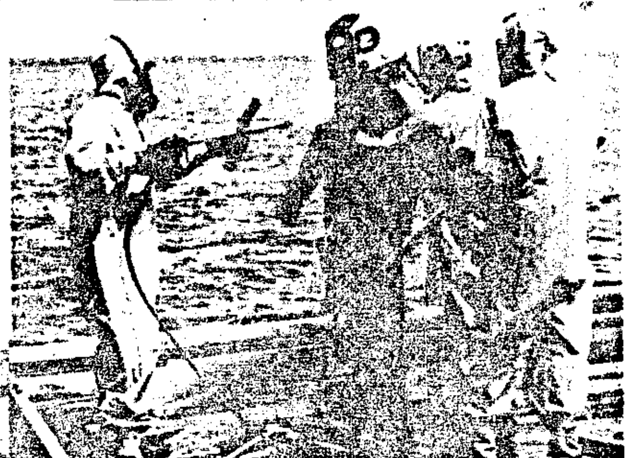
Dockside Decon of Superlite 17 Rig

Gross Initial Washdown of MK-12 Rig

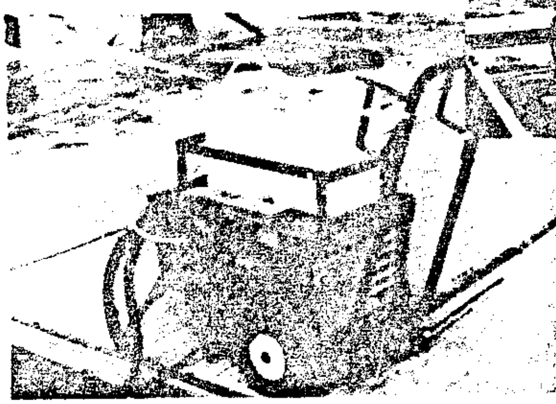
Final Decon of MK-12 Rig

Figure 24.3 Dockside Decon Operations

Initial Gross In-Water
Contaminant Washdown
of Superlite 17



Final Shipboard
Decon of MK-12 Rig



Pressure Washer w/
Concentrated Decon
Solutions

Figure 24.4 Shipboard Decon Operations

Table 24.1 USES OF GENERAL PURPOSE DECON SOLUTIONS

TYPE OF HAZARD SUSPECTED	SOLUTION	INSTRUCTIONS
1. Inorganic acids, metal processing wastes.	A	To 10 gallons of water, add 4 pounds of sodium carbonate (soda lime) and 4 pounds of trisodium phosphate. Stir until evenly mixed.
2. Heavy metals: mercury, lead, cadmium, etc.	A	Same as #1 above.
3. Pesticides, fungicides, chlorinated phenols, dioxins, and PCB's.	B	To 10 gallons of water, add 8 pounds of calcium hypochlorite. Stir with wooden or plastic stirrer until evenly mixed.
4. Cyanides, ammonia, and other non-acidic inorganic wastes.	B	Same as #3 above.
5. Solvents and organic compounds, such as trichloroethylene, chloroform, and toluene.	C (or A)	To 10 Gallons of water, add 4 pounds of trisodium phosphate. Stir until evenly mixed.
6. PBB's and PCB's.	C (or A)	Same as #5 above.
7. Oily, greasy unspecified wastes.	C	Same as #5 above.
8. Inorganic bases, alkali, and caustic waste.	D	To 10 gallons of water, add 1 pint of concentrated hydrochloric acid. Stir with a wooden or plastic stirrer.

general purpose decontamination solutions (some ingredients are available at hardware or swimming pool supply stores) are listed below:

- <u>Decon Solution A</u> - A solution containing 5% Sodium Carbonate (Na_2CO_3) and 5% Trisodium Phosphate (Na_3PO_4).
- <u>Decon Solution B</u> - A solution containing 10% Calcium Hypochlorite ($Ca(ClO)_2$).
- <u>Decon Solution C</u> - A solution containing 5% Trisodium Phosphate (Na_3PO_4). This solution can also be used as a general purpose rinse.
- <u>Decon Solution D</u> - A dilute solution of Hydrochloric Acid (HCl).

All diving helmets, jocking harnesses, weight belts, and umbilicals must be thoroughly scrubbed, deconned, and rinsed after each operational day.

Insofar as possible, measures should be taken to prevent contamination of sampling and monitoring equipment. Sampling devices become contaminated, but monitoring instruments, unless they are splashed, usually do not. Once contaminated, instruments are difficult to clean without damaging them. Any delicate instrument which cannot be decontaminated easily should be protected while it is being used. It should be bagged, and the bag taped and secured around the instrument. Openings are made in the bag for sample intake.

The following are specific areas of concern in decontamination operations:

1. Sampling devices

   Sampling devices require special cleaning. The EPA Regional Laboratories can provide information on proper decontamination methods.

2. Tools

   Wooden tools are difficult to decontaminate because they absorb chemicals. They should be kept on site and handled only by protected workers. At the end of the response, wooden tools should be discarded. For decontaminating other tools, Region Laboratories should be consulted.

3. Respirators

   Certain parts of contaminated respirators, such as the harness assembly and leather or cloth components, are difficult to decontaminate. If grossly contaminated, they may have to be discarded. Rubber components can be soaked in soap and water and scrubbed with a brush. Regulators must be maintained according to manufacturer's recommendatons. Persons responsible for decontaminating respirators should be thoroughly trained in respirator maintenance.

4. Heavy Equipment

Bulldozers, trucks, back-hoes, bulking chambers, and other heavy equipment are difficult to decontaminate. The method generally used is to wash them with water under high pressure and/or to scrub accessible parts with detergent/water solution under pressure, if possible. In some cases, shovels, scoops, and lifts have been sand blasted or steam cleaned. Particular care must be given to those components in direct contact with contaminants such as tires and scoops. Swipe tests should be utilized to measure effectiveness.

5. Sanitizing of Personnel Protective Equipment

Respirators, reusable protective clothing, and other personal articles not only must be decontaminated before being reused, but also sanitized. The inside of masks and clothing becomes soiled due to exhalation, body oils, and perspiration. The manufacturer's instructions should be used to sanitize the respirator mask. If practical, protective clothing should be machine washed after a thorough decontamination; otherwise it must be cleaned by hand.

6. Persistent Contamination

In some instances, clothing and equipment will become contaminated with substances that cannot be removed by normal decontamination procedures. A solvent may be used to remove such contamination from equipment if it does not destroy or degrade the protective material. If persistent contamination is expected, disposable garments should be used. Testing for persistent contaminaton of protective clothing and appropriate decontamination must be done by qualified laboratory personnel.

7. Disposal of Contaminated Materials

All materials and equipment used for decontamination must be disposed of properly. Clothing, tools, buckets, brushes, and all other equipment that is contaminated must be secured in drums or other containers and labeled. Clothing not completely decontaminated on-site should be secured in plastic bags before being removed from the site.

Contaminated wash and rinse solutions should be contained by using step-in-containers (for example, child's wading pool) to hold spent solutions. Another containment method is to dig a trench about 4 inches deep and line it with plastic. In both cases the spent solutions are transferred to drums, which are labeled and disposed of with other substances on site.

Appendix F, Annex 1, 2, and 3 describe basic decontamination procedures for a worker wearing Level LA, B, or C protection. The basic decontamination lines (Situation 1), consisting of approximately 19 stations, are almost identical except for changes necessitated by different protective clothing or respirators. For each annex, three specific situations are described in which the basic (or full decontamination) procedure is changed to take into account differences in the extent of contaminaiton, the accompanying changes in equipment worn, and other factors. The situations illustrate decontamination setups based on known or assumed conditions at an incident. Many other variations are possible.

Annex 4 describes a minimum layout for personnel decontamination. The number of individual stations ahve been reduced. Although the decontamination equipment and amount of space required is less than needed in the procedures previously described, there is also a much higher probability of cross-contamination.