

Appendix F

Decontaminants

Decontaminants in this appendix are grouped in tables according to their classification of standard, nonstandard, and natural. See Tables F-1 through F-3. Each decontaminant is identified by name and NSN (where applicable). Some include pictures of the decontaminant or its container. The use of each decontaminant is listed as

nuclear, biological, and/or chemical, and brief directions are given on how to prepare each decontaminant. The tables also list any appropriate cautions for each decontaminant. A remarks column gives information on application, coverage, substitute solutions, and the related effectiveness of the decontaminants.

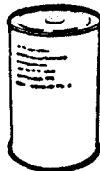
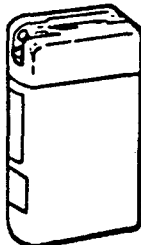
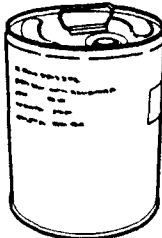
Table F-1. Standard decontaminants. (Decontaminants most often used and available in supply system)				
Decontaminant	Use	Remarks	Cautions	Preparation
Decontaminating Solution No. 2 (DS2)  DS2 in a 1-1/3 quart can NSN 6850-00-753-4827	Bio Cmi	Effective against all known toxic chemical agents and biological materials (except bacterial spores) if sufficient contact time is allowed. Allow to remain in contact with contaminated surface for approximately 30 minutes. Rinse off with water. Recheck for contamination. Can be used at temperatures from -15°F. Used with the ABC-M11 1-1/2 quart portable decon apparatus, M13 DAP, or can be applied with brooms and swabs. Most effective when application is accompanied by scrubbing action.	Extremely irritating to the eyes and skin. Protective mask and rubber gloves must be worn. If DS2 contacts skin, wash the area with water. Do not inhale vapors. Will cause a green to black color change upon contact with ABC-M8 detector paper and cause a false/positive with M9 paper. Ignites spontaneously on contact with STB and HTH. Avoid spilling DS2 on chemical protective overgarment. Combustible. Do not confuse with fire extinguisher. DS2 is a combustible liquid with a flash point of 160°F. Spraying DS2 onto heated surfaces above 168°F will ignite the DS2. Do not use on M17-series mask (damages mylar diaphragm in voicemitter assembly). Corrodes aluminum, cadmium, tin, and zinc; softens leather. May soften, remove, or discolor paint. Rinse well after use and oil metal surfaces. Ineffective against bacterial spores.	No mixing is required. Issued in ready-to-use solutions.
 DS2 in 14-liter container for M13 DAP NSN 4230-01-136-8888				
 DS2 in a 5-gallon pail NSN 6850-00-753-4870				

Table F-1 continued

Table F-1 continued. Standard decontaminants.
(Decontaminants most often used and available in supply system)

Decontaminant	Use	Remarks	Cautions	Preparation
Supertropical Bleach (STB)  NSN 6850-00-297-6653	Bio Cml	Effective against Lewisite, V and G agents, and biological agents. Allow to remain in contact with contaminated surface for at least 30 minutes, then wash off with clear water.	Ignites spontaneously on contact with liquid blister agent or DS2. Gives off toxic vapors on contact with G agent. Not recommended for ship use. Top deck storage only. Corrosive to most metals and injurious to most fabrics (rinse thoroughly and oil metal surfaces). STB mixtures (dry and slurry) do not effectively decon mustard if it has solidified at low temperatures. Porous surfaces may require several applications. Should not be inhaled or come in contact with the skin. Protective mask or other respiratory protection device should be worn when preparing slurry. Store in unheated warehouse isolated from combustibles and metals subject to corrosion.	Slurry Paste —Mix one 50-lb drum of STB with 6 gal of water. Slurry paste consists of approximately equal parts (by weight) of STB and water. Dry Mix —2 shovels STB to 3 shovels earth or inert material (such as ashes). Slurry Mix — Chemical —Slurry mix will consists of 40 parts STB to 60 parts water (by weight). To mix in M12A1 use 1,300 lb. STB, 225 gal water, 12-1/2 lb antiset, 24 oz antifoam. Biological —Slurry mix will consist of 7 parts STB to 93 parts water (by weight). To mix in M12A1 use 150 lb STB, 225 gal water, 1-1/2 lb antiset, 24 oz antifoam. Camouflage —Lampblack or dye mixes may be added for camouflage. No mixing.
Mask Sanitizing Solution	Bio Cml	Used on previously cleaned masks with filter elements removed. Place mask face up. Attach canteen to mask at the drinking tube. Drain one canteen full of sanitizing solution through the mask. Follow with two canteens of clean water as a rinse. Immerse mask and outserts in sanitizing solution. Agitate for 5 minutes. Rinse twice in clear water, agitating 2 or 3 minutes each time. Dry all parts and reassemble mask.	1 gallon of solution needed for every ten masks.	Fill standard plastic canteen to shoulder with water. Add one 0.5 gram tube calcium hypochlorite from water purification kit (NSN 6810-00-266-6979). Cover canteen and shake vigorously for 30 seconds. Mix bulk quantities as follows—add 2.0 grams (.08 oz) of calcium hypochlorite from 6-oz jar (NSN 6810-00-255-0471) to 1 gallon of water.
Soap and Detergents Detergent, general purpose, liquid (NSN 7930-00-282-9699)	Nuc Bio Cml	Scrub or wipe contaminated surfaces with hot, soapy water solution or immerse item in the solution.	Soaps and detergents are effective in physically removing contamination. However, casualty-producing levels of contamination may remain in the runoff water which must be considered contaminated.	Mix 75 lb of powdered soap in 350 gal of water. If powdered soap is not available, bar laundry soap may be used (75 lb of soap, cut into 1-inch pieces and dissolved in 350 gal hot water). For smaller amounts of soap solution, use a ratio of approximately 1 lb soap per gal of water. Mix 2-pints detergent to 450 gallons water in M12A1 PDDE.

Tables continued

**Table F-2. Nonstandard Decontaminants.
(Decontaminants not frequently used)**

Decontaminant	Use	Remarks	Cautions	Preparation
Oxidizing Agents (potassium permanganate, potassium or sodium dichromate, nitric acid, or aqua regia)	Nuc	Effective in dissolving surfaces containing adsorbed or absorbed radioactive contamination. Dip into or coat surface with oxidizing agent. Exposure must be limited due to corrosive nature of solution. Rinse thoroughly with water and detergent and then with clear water.	Extremely corrosive. Use only under the supervision of an individual trained in their use. Neoprene or rubber protective apron, gloves, boots, and safety glasses must be worn. (Rubber offers only limited protection.)	Aqua regia is prepared by mixing 3 parts of concentrated hydrochloric acid and 1 part concentrated nitric acid. Other oxidizing agents do not require mixing.
Complexing (Chelating) Agents (versene, sequesterene, citric acid, sodium citrate, tartaric acid, sodium tartrate, oxalic acid, sodium oxalate, orthophosphoric acid, and similar agents)	Nuc	Aids in removal of contamination that is absorbed on surfaces. Apply as a film over contaminated surface using PDDA, fire fighting apparatus, or tree or garden sprayer. Allow 30 minutes contact time and flush with water.	Aids in physical removal of contamination but does not neutralize contamination. Runoff residue will be contaminated.	Mix 3 to 5 percent of agent (by weight) in water.
Iodine Water Purification Tablets	Bio	Where boiling of drinking water is impractical, two iodine tablets per canteen of water (Proper instructions on container) are effective against most biological agents.	None.	None.
Disinfectant, Chlorine, Food Serve (NSN 6840-00-270-8172)	Bio	Effective for decon of utensils, mess gear, the exteriors of sealed containers, and food products that can withstand soaking. Dispose of any food or vegetable that is damaged and any outer leaves that are bruised or torn. Do not cut or peel fruits and vegetables before disinfecting them. Leave items in solution for 30 minutes and stir occasionally to insure that surfaces are kept thoroughly wet. Utensils may be disinfected by immersing in solution for 30 seconds. Rinse thoroughly in potable water. Do not use solutions more than once. If this disinfectant is not available, an emergency solution prepared by mixing at least one level mess kit spoonful of calcium hypochlorite (water disinfecting powder) to each 10 gal of water. If liquid chlorine bleach is available, it may be used. About one-third canteen cup of 5 percent chlorine bleach to each 10 gal of water will produce the same disinfecting strength. Fresh solutions must be made for rinsing and disinfecting utensils for each 100 persons.	None.	Dissolve one package of disinfectant in 20 gal of warm potable water (100°F).

Table F-2 continued

Table F-2. continued. Nonstandard Decontaminants.
(Decontaminants not frequently used)

Decontaminant	Use	Remarks	Cautions	Preparation
Formalin (formaldehyde)	Bio	Effective against all microorganisms, to include bacterial spores. Recommended as interior decontaminant for relatively closed areas. Allow vapors to remain 16 hours in a closed structure, then aerate until odor is no longer objectionable. Optimum conditions for spraying are 70° to 80°F. 85 percent relative humidity. The minimum effective relative humidity is 70 percent. The minimum effective temperature is 60°F. at which the exposure time should be increased to 24 hours. Apply as vapor from standard insecticide sprayers or vaporize by heat or bubbling steam through pan of decontaminant.	Formalin vapors are very toxic. Will curl and discolor paper. Will leave white residue. Up to 72 hours aeration may be required. A self-contained breathing apparatus should be worn when remaining for more than a few minutes in a building containing formalin vapors. Personnel handling or spraying formalin should wear impermeable protective clothing. Personnel entering an area containing formalin vapor for only a few minutes should— • Wear protective mask. • Wear washable outer clothing, fastened to prevent vapor from entering at wrist, ankles, or neck. • Remove outer clothing after emerging from vapor. • Shower and put on clean clothing as soon as possible. Vapors of formalin are not flammable; open flame should not be used for vaporizing when methanol has been added to formalin. When steam is used, source of steam should be outside area being decontaminated.	No mixing required. However, less residue remains and less aeration is required if mixture of 5 parts formalin and 3 parts methanol are used. (Use this mixture at rate of 4/5 qt per 1,000 cu ft of space.
Detrochlorite	Bio	A thickened bleach useful on vertical surfaces. Apply by means of a PDDA. Allow 30 minutes contact time, then rinse with water. Coverage is 1 gal per 8 sq yd.	Very corrosive. See "Preparation" column.	Mix by weight 19.3 percent diatomaceous earth, 0.5 percent anionic wetting agent, 2.9 percent calcium hypochlorite (70 percent available chlorine), 77.3 percent water. Mix wetting agent and diatomaceous earth with water before adding the calcium hypochlorite. Mixing the wetting agent and calcium hypochlorite in a dry undiluted state may cause an explosion.
Paracetic Acid (PAA)	Bio	Effective against all microorganisms to include bacterial spores. Allow 10 minutes contact time. Wipe item with rag or swab, remove excess acid, and aerate 10 to 15 minutes, or until no objectionable odor remains. Immerse small items for 10 minutes, remove excess acid, and aerate until no objectionable odor remains.	Fumes highly irritating. Prolonged exposure will damage most materials. 40 percent solution has low flash point (105°F); 3 percent solution is nonflammable. Will cause burns and blister skin. Must be stored in original containers under refrigeration to prevent decomposition. Protective clothing and mask are required. A violent explosion may result if heavy metal ions come in contact with peracetic acid. Prolonged exposure will corrode iron and deteriorate rubber, plastics, and leather.	Available as 40 percent solution. Mix 1 qt to 3-1/2 gal of water (add peracetic acid to water).

Table F-2 continued

**Table F-2. continued. Nonstandard Decontaminants.
(Decontaminants not frequently used)**

Decontaminant	Use	Remarks	Cautions	Preparation
Ethylene Oxide (ETO)	Bio	Effective against all microorganisms to include spores. Apply 30 lb for every 1,000 cu ft. Allow 6 hours contact time (contact time must be doubled for each 20°F drop in temperature below 75°F). Airtight enclosure required.	ETO is flammable. Not recommended for interior use (see carboxide below).	None
Carboxide	Bio	Carboxide is a mixture of ethylene oxide and carbon dioxide that is effective against all microorganisms to include spores. Apply 30 lb for every 1,000 cu ft. Allow 12 hr contact time (contact time must be doubled for each 20°F drop in temperature below 75°F.) Carboxide is nonflammable and is recommended for interior use. Airtight enclosure required.	Will blister skin. Items worn next to skin must be aerated 18 to 24 hr.	None
Hyamine (Benzethonium chloride)	Bio	Effective against all bacteria. Allow 5 to 30 minutes contact time.	Very toxic. Estimated fatal dose to man 1 to 3 grams. Care should be taken when mixing to avoid inhalation of powder. Not to be used on ships.	Use a 0.1 to 1 percent solution (1 lb hyamine for every 12 gal of water yields 1 percent solution).
Sodium Hypochlorite Solution (household bleach)	Bio Cml	Effective against blister and V agents and all biological materials. Reacts rapidly (within 5 minutes) with blister and V agents. Allow 10 to 15 minutes contact time for biological materials. Possible sources—commercial laundry (19 to 14 percent solution) or food store (5 percent solution such as Purex or Clorox®). Apply undiluted with brooms, brushes, or swabs. Preferred decontaminant for ship use. For ship use, a 5 to 1 concentration is recommended. Limited storage problem.	Undiluted, it is harmful to skin and clothing. Remove from skin and clothing by flushing with water. Corrosive to metals unless rinsed, dried, and lubricated after decon. Store in cool place.	No mixing required for chemical decon. For biological decon, dilute by adding 2 parts bleach to 10 parts water. For decon of cotton clothing and utensils, bleach should be diluted 1/2 cup bleach to 1 gal water. Dilute half and half with water and spray from PDDE.
Calcium Hypochlorite (HTH) (high test bleach, HTB, or high test hypochlorite) NSN 6810-264-6591 (25 lb) NSN 6810-664-0402 (100 lb)	Bio Cml	Effective against Lewisite, V agents, and all biological materials including bacterial spores. Reacts rapidly (within 5 minutes) with mustard and Lewisite. Allow 15 minutes contact time for biological materials. Faster acting than STB. Can be used as a dry mix or a slurry.	Observe same precautions as for STB. Pure undiluted calcium hypochlorite will burn on contact with VX, HD, or DS2. More corrosive than STB. Will destroy clothing, has a toxic vapor, and will burn the skin. Protective mask and rubber gloves are the minimum protective equipment for handling calcium hypochlorite.	Chemical —Mix 5 lb decontaminant to 6 gal of water (10 percent solution). Biological —Mix 1 lb decontaminant to 6 gal water (2 percent solution). PDDE —Mix a slurry of 1 part decontaminant to 2 parts water (any heavier slurry will clog the decon apparatus). Use only if STB is not Available.

Table F-2 and Calcium Hypochlorite continued

Table F-2. continued. Nonstandard Decontaminants.
(Decontaminants not frequently used)

Decontaminant	Use	Remarks	Cautions	Preparation
Calcium Hypochlorite continued	Bio Cml	Not recommended for ships. Top deck storage only. Not allowed in slurry or dry form in holds of vessels. Possible sources, commercial laundry, drug store, or chemical firm.	Skin or clothing that comes in contact with decontaminant should be flushed with large amounts of water. Equipment that has been used to spray decontaminant must be thoroughly cleaned after the spray mission (thoroughly rinse with hot water, 80°C or 176°F).	A slurry of 3 parts HTH and 97 parts water can be used for horizontal surfaces. Approximate coverage is 1 gallon per 8 sq yd.
2-Propanone (acetone)	Cml	Melting point -95.35°C; boiling point 56.2°C. Evaporates rapidly. Good decontaminant for use in arctic regions. Commonly obtained as finger-nail-polish remover or paint thinners. Scrubbing increases effectiveness.	Extremely flammable. Does not neutralize agents. Effective for dissolving and flushing agent by physically removing.	None
Diethyl Ether	Cml	Melting point -116.2°C; boiling point 34.15°C. Good decontaminant for use in arctic regions. Available through medical supply facilities. Scrubbing increases effectiveness.	Same as 2-propanone.	Same as 2-propanone.
Ethylene Glycol	Cml	Contaminated surfaces should be scrubbed with decontaminant and thoroughly rinsed.	Effective in physically removing contamination, but does not neutralize the contamination. Runoff residue must be considered contaminated.	Mix 50 percent solution to 50 percent water.
Solvents (gasoline, JP-4, diesel fuel, kerosene, and similar solvents)	Cml	Contaminated surfaces should be scrubbed with decontaminant and thoroughly rinsed.	Same precautions listed for ethylene glycol are applicable to solvents. Solvents may damage materials such as rubber and plastic.	None
Sodium Hydroxide (caustic soda or lye) NSN 6810-174-6581 (100 lb)	Bio Cml	Effective against G agents, lewisite, and all biological materials including bacterial spores. Neutralizes G agents on contact. Allow to remain in contact with surface contaminated with chemical agent for approximately 15 minutes.	Damaging to skin, eyes, and clothing on contact in either solution or solid form. Inhalation of the dust or concentrated mist can cause upper respiratory or lung damage. Full rubber protective clothing, gloves, boots, and mask required. In case of contact, wash area immediately with large amounts of water, flush with diluted acetic acid or vinegar. Remove affected clothing immediately. If eyes are involved, flush them at once with large amounts of warm water and get medical attention. Runoff from decon operations is highly corrosive and toxic. Drain runoff into sump and bury.	Small amount —10 lb lye to 12 gal water (10 percent solution). Mix in an iron or steel container (never aluminum, zinc, or tin). Add lye to water to prevent boiling and splattering due to excessive heat emitted. Do not handle mixing container with bare hands. Large amount —(PDDE use) Prepare a solution of 227 grams (1/2 lb) of lye for each gal of water. Pump 350 gal of water into tank unit. Connect tank unit and pump unit and heater together. Heat water to 50°C (122°F). Disconnect heater unit and add 79 kg (175 lb) of lye (1-3/4 drums) to the heated water. Circulate solution with the pump unit until all lye is dissolved. The temperature will increase noticeably. Use while hot.

Table F-2 and Sodium Hydroxide continued

Table F-2. continued. Nonstandard Decontaminants.
(Decontaminants not frequently used)

Decontaminant	Use	Remarks	Cautions	Preparation
Sodium Hydroxide continued	Bio Cml		All equipment should be flushed with large amounts of clear water to minimize the danger of operators being burned by residual deposits. Not recommended for ship use. Top deck storage only. The M12A1 PDDE will withstand the highly corrosive action of caustic soda solutions. However, thorough rinsing after use is necessary. Corrosive to most metals. Effectiveness is directly proportional to strength of solution. Lye is not recommended as a decontaminant if less caustic decontaminants are available. Will cause a red-color change upon contact with M8 paper.	Simultaneous mixing and applying—Sprinkle dry lye on the contaminated area and then dissolve it with a spray of steam or hot water. Do not wash the lye off the surface while applying the steam or hot water. Paint removal—1 lb lye per 2-1/2 gal of water is capable of removing an average coat of paint from about 11 sq yd of surface. This solution is effective in removing paint onto which chemical contamination has absorbed. (Calcium hydroxide, potassium hydroxide, or trisodium phosphate may be substituted for sodium hydroxide.)
Sodium Carbonate (washing soda, soda ash, sal soda, or laundry soda)	Cml	Effective against G agents and CN. Reacts rapidly with G agents, normally within 5 minutes. Preferred decontaminant for ship use. Recommended 5 percent by weight concentrations. No storage problem. A hot solution is the most effective means of decontaminating CN.	Do not use for VX. It can not detoxify VX and creates extremely toxic by-products. HD does not dissolve in solution and is not detoxified.	Mix 10 lb washing soda to 12 gal water (10 percent solution).
Potassium Hydroxide (caustic potash)	Bio Cml	Same remarks applicable to sodium hydroxide apply to potassium hydroxide.	Same precautions applicable to sodium hydroxide apply to potassium hydroxide.	Same preparations as used for sodium hydroxide are used for potassium hydroxide.
Hexachloramelamine	Cml	Effective against mustard agents.	Protective mask and rubber gloves should be worn when working with hexachloramelamine. Corrosive to metal.	Decontaminant is a powder that is not soluble in water, but is soluble in organic solvents such as gasoline, kerosene, and paint thinner.
Ammonia or Ammonium Hydroxide (household ammonia)	Cml	Effective against G agents. Slower acting than sodium hydroxide or potassium hydroxide.	Self-contained breathing apparatus or special purpose mask required when working with ammonia or ammonium hydroxide.	Ammonium hydroxide is a water solution of ammonia. No further mixing is required.
Perchloroethylene (tetrachloroethylene)	Cml	Melting point -22°C; boiling point 121°C, good for use in arctic climates. A nonflammable, synthetic solvent widely used in dry cleaning plants. Dissolves H and V agents but not G. Low toxicity.	Physically dissolves and removes contamination but does not neutralize it.	No mixing required (practically insoluble in water). Effectiveness increased with scrubbing.
Dichloramine-B and Dichloramine-T	Cml	Effective against mustard agents.	Protective mask and rubber gloves should be worn when working with decontaminant. Corrosive to metal.	Decontaminant is a powder that is not soluble in water but is soluble in certain organic solvents. Normally mixed as a 10 percent solution in dichloroethane.

Table F-2 continued

Table F-2. continued. Nonstandard Decontaminants.
(Decontaminants not frequently used)

Decontaminant	Use	Remarks	Cautions	Preparation
Acids (sulfuric acid, hydrochloric acid, acetic acid, oxalic acid, and similar acids)	Nuc	Effective solvents for rust and mineral deposits holding radioactive material on metal surfaces. Normally allow 1 hour contact time. Flush with water, scrub with a water-detergent solution, flush again with water.	Acids are difficult to handle. They are harmful to the body, particularly the eyes. Mixing acids or acid and water can produce boiling and splattering of the solution. Rubber boots, rubber gloves, rubber aprons, and goggles should be worn. Respiratory protection required in closed areas. In case of body contact with acid, flush area immediately with water. A 5 percent solution of water and baking soda (sodium bicarbonate) is used to wash acid from eyes and body. This solution neutralizes the acid.	None.
Miscellaneous Solutions	Cml	To be effective, these solutions should be scrubbed onto the contaminated surfaces.	None	MEA solution—10 percent monoethanolamine, 1.0 percent 9N9-nonionic surfactant (triton X100) in water. WGD (C-8) solution—302 gal water, 250 lb HTH, 36 gal perchloroethylene, and 33 lb IHF emulsifier. ASH solution—0.2 percent pure $\text{Ca}(\text{OCl})_2$ from STB in water buffered to a pH of 7.53 with NaH_2PO_4, Na_2HPO_4, and .05 percent triton X100 surfactant. Slash solution—aqueous hypochlorite salt, aqueous citric acid, sodium citrate buffer with detergent in equal proportion (pH 7.5).

Tables continued

Table F-3. Natural decontaminants.
(Decontaminants readily available and frequently occurring in nature)

Decontaminant	Use	Remarks	Cautions	Preparation
Water	Nuc Bio Cml	Flush contamination from surfaces with large amounts of water.	Effective in physically removing contamination, but does not neutralize the contamination.	None.
Steam	Nuc Bio Cml	The use of steam accompanied by scrubbing is more effective than the use of steam alone.	Effective in physically removing contamination. However, contamination may not be neutralized.	None.
Absorbents (earth, sawdust, ashes, rags, and similar materials)	Cml	Used to physically remove gross contamination from surfaces.	The contamination is transferred from the surface to the absorbent. The absorbent becomes contaminated and must be disposed of accordingly. Sufficient contamination to produce casualties may well remain on surfaces.	
Sealants (concrete, asphalt, earth, paint, and similar materials)	Nuc Bio Cml	Used to physically seal in or shield contamination. Various sealants are effective as follows – ● 12 inches of earth provides good protection from fallout (3 inches will reduce the dose rate by about one half). ● 1 inch of asphalt or concrete completely absorbs alpha and beta radiation. ● 1/4 inch of grout shields alpha and beta radiation. ● Burying items contaminated with biological agents is an effective means of sealing off contamination. ● 4 inches of earth provides good protection from chemical contamination.	A break in the surface of the sealant will expose the contamination. Contaminated areas covered with sealants must be marked with appropriate NBC warning signs.	None.