NAHEMS GUIDELINES:
CLEANING AND DISINFECTION

FAD PReP
Foreign Animal Disease
Preparedness & Response Plan

USDA

NAHEMS
National Animal Health
Emergency Management System

the Center for Food Security & Public Health
Iowa State University

United States Department of Agriculture • Animal and Plant Health Inspection Service • Veterinary Services

JULY 2014

The Foreign Animal Disease Preparedness and Response Plan (FAD PReP)/National Animal Health Emergency Management System (NAHEMS) Guidelines provide a framework for use in dealing with an animal health emergency in the United States.

This FAD PReP/NAHEMS Guidelines was produced by the Center for Food Security and Public Health, Iowa State University of Science and Technology, College of Veterinary Medicine, in collaboration with the U.S. Department of Agriculture Animal and Plant Health Inspection Service through a cooperative agreement. The content has undergone review by USDA Legislative and Public Affairs.

This FAD PReP/NAHEMS Guidelines reflects review and minor corrections to the 2011 version, completed in July 2014. Please send questions or comments to:

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PREFACE

The Foreign Animal Disease Preparedness and Response Plan (FAD PReP)/National Animal Health Emergency Response System (NAHEMS) Guidelines provide the foundation for a coordinated national, regional, state and local response in an emergency. As such, they are meant to complement non-Federal preparedness activities. These guidelines may be integrated into the preparedness plans of other Federal agencies, State and local agencies, Tribal Nations, and additional groups involved in animal health emergency management activities.

The Cleaning and Disinfection Guidelines are a component of APHIS' FAD PReP/NAHEMS Guideline Series, and are designed for use by APHIS Veterinary Services (VS), and other official response personnel in the event of an animal health emergency, such as the natural occurrence or intentional introduction of a highly contagious foreign animal disease in the United States.

The Cleaning and Disinfection Guidelines provide guidance for USDA employees, including National Animal Health Emergency Response Corps (NAHERC) members, on cleaning and disinfection principles for animal health emergency deployments. This Guideline provides information for Cleaning and Disinfection Group Supervisors and other personnel associated with cleaning and disinfection activities. The general principles discussed in this document are intended to serve as a basis for making sound decisions regarding cleaning and disinfection. As always, it is important to evaluate each situation and adjust procedures to the risks present in the situation.

The FAD PReP/NAHEMS Guidelines are designed for use as a preparedness resource rather than as a comprehensive response document. For more detailed response information, consult the FAD PReP Standard Operating Procedures (SOP): 15. Cleaning and Disinfection and plans developed specifically for the incident. Additional cleaning and disinfection resources are included in the Appendix and in the references at the end of this document.

APHIS DOCUMENTS

This "FAD PReP/NAHEMS Guidelines: Cleaning and Disinfection" has corresponding disease-specific FAD PReP Standard Operating Procedures (SOP): 15. Cleaning and Disinfection.

Several key APHIS documents complement this "FAD PReP/NAHEMS Guidelines: Cleaning and Disinfection" and provide further details when necessary. This document references the following APHIS documents:

- FAD PReP/NAHEMS Guidelines:
    - Biosecurity
    - Health and Safety
    - Personal Protective Equipment
    - Wildlife Management and Vector Control

- FAD PReP Standard Operating Procedures (SOP):
    - 15. Cleaning and Disinfection

These documents are available on the public APHIS FAD PReP website: http://www.aphis.usda.gov/fadprep.

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Guidelines: Cleaning and Disinfection (C&D)

1. INTRODUCTION

Cleaning and disinfection (C&D) procedures are a crucial part of any animal health emergency response situation. The potential for spread or transfer of microorganisms, especially highly contagious pathogens, can occur from the direct or indirect contamination of premises, equipment, vehicles or personnel and the movement of animals or animal products. C&D procedures are used to inactivate or destroy microorganisms, thereby inhibiting or eliminating their further spread. These efforts are vital for disease control and eradication measures. When correctly implemented, C&D procedures can be a cost-effective means of minimizing pathogenic threats. Personnel involved with C&D functions must be knowledgeable about general C&D principles, methods and procedures for the variety of situations that may occur during an animal health emergency. This document provides guidance on C&D processes and procedures and includes information gleaned from the literature as generally accepted disinfection practices.

2. DEFINITIONS

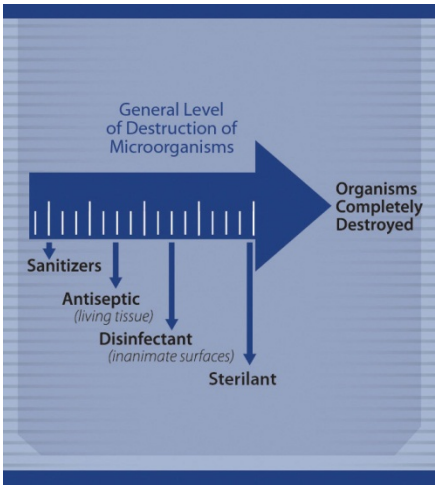
Cleaning and disinfection involves the use of physical or chemical processes to reduce, remove, inactivate, or destroy pathogenic microorganisms. These processes vary in their level of destruction of microorganisms. Understanding the differences between C&D processes and products is important when determining the necessary procedures to implement for a specific situation.

Detergent – Chemical products used to disperse and remove soil and organic materials from surfaces by reducing surface tension and increasing the penetrating ability of water. This can improve a disinfectant's ability to reach and destroy microorganisms within or beneath the organic material. Some disinfectants (i.e., quaternary ammonium compounds) have detergent properties.

Sanitizer – A substance that reduces the bacterial population in the inanimate environment by significant numbers, but does not destroy or eliminate all bacteria or other microorganisms.

Antiseptic –Products approved and used to reduce the risk of infection by killing or inhibiting the growth of microorganisms on the skin. Because these products are used in or on humans or animals, they are considered drugs and are approved and regulated by the U.S. Food and Drug Administration (FDA).

Disinfectant – A substance used on inanimate surfaces that destroys or eliminates a specific species of infectious or other public health microorganism, but not necessarily bacterial spores. Disinfectants are registered as "antimicrobial pesticides" and regulated by the U.S. Environmental Protection Agency (EPA). Disinfection can also be achieved by physical means (e.g., heat, ultraviolet light).

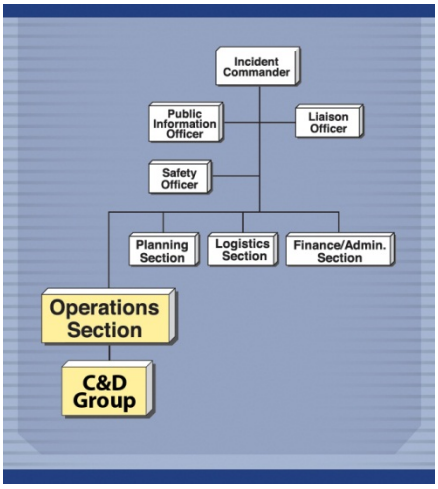


Sterilant – A substance that destroys or eliminates all forms of microbial life in the inanimate environment, including vegetative bacteria, bacterial spores, fungi, fungal spores, and viruses. Sterilization can also be achieved by physical means (e.g., heat, ultraviolet, and irradiation).

Further definitions of key terms used in this document can be found in the Glossary.

3. THE CLEANING AND DISINFECTION GROUP

During an animal health emergency, the Cleaning and Disinfection Group functions as part of the Operations Section of the Incident Command System (ICS) to coordinate on-site C&D efforts. This may include establishing, supervising, and performing cleaning and disinfection protocols for infected or quarantined premises as well as setting up disinfection stations for vehicles, equipment, and personnel. C&D personnel may also serve to assess and address compliance with C&D protocols and regulations.



All C&D personnel should read and understand the procedures discussed in these guidelines. C&D personnel should also be trained or familiar with the use and proper maintenance of equipment used for C&D as well as the hazards and factors influencing efficacy of disinfection processes and procedures. Review of additional information sources (see the References and Internet Resources) and participation in educational sessions and/or emergency response exercises will help to expand knowledge and expertise of C&D principles and procedures for animal health emergency management situations.

The number of personnel for a C&D Group will vary depending on the size and scope of the incident. Key C&D personnel would include the following:

(a) The C&D Group Supervisor, based at the Incident Command Post, who is in charge of all C&D Teams (Strike Team and Task Force) and C&D Team Members
(b) C&D Team Leaders who supervise C&D Teams. Two types of teams may be deployed, a Strike Team or a Task Force.
(c) C&D Teams who are responsible for activities at specific premises, C&D stations, or checkpoints; members may include personnel with expertise from multiple government and private sources.

3.1 Functions of the C&D Group

USDA-APHIS VS personnel may either supervise or perform the actual C&D operations of the infected premises. Additional functions of the C&D Group include the following:

- Provide input to the Command level on C&D procedures (e.g., technical advice, briefings, daily reports)
- Provide technical advice on C&D issues to owners or operators of infected or contact premises
- Coordinate closely with the Logistics Section to secure the necessary equipment and supplies and ensure an ample supply of chemical disinfectant products
- Coordinate C&D Team activities with other response Groups (e.g., Surveillance, Appraisal, Biosecurity)
- Establish, operate, and maintain C&D stations as needed, including quarantined premises, vehicle entry and movement control checkpoints, and personnel decontamination stations
- Provide personnel to supervise C&D activities
- Schedule and certify C&D procedures on the infected premises or other affected areas

3.2 Roles and Responsibilities

3.2.1 Cleaning and Disinfection Group Supervisor

The C&D Group Supervisor should be identified well before an animal health emergency occurs. This individual is assigned to the Incident Command Post and reports to the Disease Management Branch Director or Operations Section Chief. This individual is in charge of all C&D Teams and has the primary responsibility for ensuring that C&D measures are implemented effectively during an animal disease emergency, and that all C&D personnel are familiar with the proper C&D techniques to manage or eliminate transmission of the pathogen. This individual should have extensive training and/or experience in the proper cleaning and disinfection methods following an animal disease emergency and possess the management skills needed to organize and direct all C&D activities for the incident.

The C&D Group Supervisor should work with State emergency management agencies to identify C&D Team Members with required expertise from multiple government and private sources. They should also inform the Operations Section Chief of any personnel requirements that cannot be satisfied locally so that arrangements for additional personnel can be made. The C&D Group Supervisor will also work with appropriate officials to issue contracts and leases regarding equipment or personnel for the C&D operations.

Additional duties of the C&D Group Supervisor include the following:

- Maintaining up-to-date contact information on personnel willing and qualified to serve as C&D Group members
- Maintaining a working knowledge of State and Federal regulations pertaining to the use of C&D products or processes and proper effluent management
- Determining the number and types of personnel, vehicles, and equipment needed to conduct C&D operations; this includes communicating with the Operations Section Chief to ensure that the required resources are available
- Identifying personnel training requirements and orienting new employees to the specifics of their duties within the C&D Group
- Assigning C&D personnel as necessary to achieve the goals of the Incident Commander
- Ensuring that the Safety Officer orients all new personnel regarding on-the-job hazards
- Coordinating C&D Group activities with other response Groups (e.g., Animal Biosecurity and Disease Prevention, Disease Survey, Appraisal)
- Supervising all personnel assigned to the C&D Group
- Coordinating with farm owners and/or managers regarding all phases of C&D
- Establishing and maintaining C&D stations as needed
- Verifying the accuracy and completeness of all required reports and submitting them promptly to the USDA-APHIS Emergency Management Response System (EMRS) or a similar acceptable reporting system
- Informing any industry groups involved of the location of C&D stations and the need to use them. Affected industry groups may include renderers, feed-mill operators, transportation company representatives, livestock and poultry producers, processing-plant managers, and others.
- Preparing regular briefings and reports for the Operations Section Chief and notifying him or her immediately of any problems
- Cooperating with appropriate animal health emergency groups

3.2.2 Cleaning and Disinfection Team Leaders

A C&D Team Leader supervises the on-site activities of a C&D Team and is typically given responsibility for one of the specific C&D functions which have been identified or determined for a particular incident. In a large incident, different C&D Team Leaders may supervise and manage personnel

or vehicle disinfection stations and/or, premises and checkpoint equipment disinfection. These tasks will involve on-site coordination with the Biosecurity Team.

Additional roles and responsibilities of the C&D Team Leader include

- Assisting the C&D Group Supervisor in determining the personnel, vehicles, and equipment required to operate the C&D activities efficiently;
- Orienting and training C&D Team Members on policies, procedures, and assigned tasks;
- Assigning tasks (e.g., operation of C&D at a checkpoint or supervision of C&D on premises) to C&D Team Members and supervising their work;
- Serving as liaison to premises owner or manager for technical questions related to C&D;
- Arranging and coordinating required C&D for all vehicles, equipment, and other materials leaving an infected, contact, or suspect premises;
- Providing C&D support to the Biosecurity Team, including liaison with the assigned Biosecurity Team Member who is the permanent guard on infected premises;
- Maintaining knowledge of disease prevention principles and practices; and
- Preparing regular briefings and reports for the C&D Group Supervisor and notifying him or her immediately of any problems or issues.

3.2.3 Cleaning and Disinfection Team Member

The C&D Teams are responsible for conducting cleaning and disinfection activities at specific premises, C&D stations or checkpoints. There may be several C&D Teams depending on the characteristics of the premises (e.g., number of buildings, size of buildings and area, sanitary conditions of the premises) and the time frame with which the work can or must be completed. Each team will typically be composed of multiple C&D Team Members.

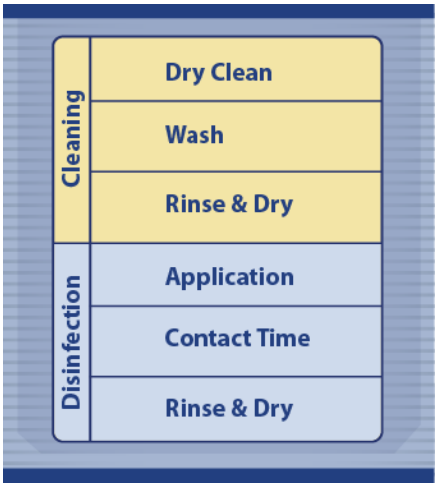
Some events may require either a C&D Strike Team or a C&D Task Force:

- The C&D Strike Team – A specified combination of the same kind and type of resources with common communications and a Leader
- The C&D Task Force – A combination of single resources assembled for a particular tactical need with common communications and a Leader

Personnel serving on a C&D Team may be drawn from a number of sources. USDA-APHIS and State cooperators have Animal Health Technicians with the training and experience to supervise C&D and, if necessary, to handle and apply C&D products. Local pest control companies have experience in working with the spray equipment and pressure pumps commonly used in C&D. In the agricultural community, there are businesses which specialize in C&D of facilities. Members of the military from the Department of Defense may be available through Memorandums of Understanding between Departments. Local hires can be trained for specific application activities.

In addition, “3D” Teams are available through the National Veterinary Stockpile, and enlist large numbers of trained and equipped personnel to support States that have limited personnel for depopulation, disposal and decontamination activities. A diagram showing a sample Incident Command diagram for animal health emergencies can be found in Appendix B.

4. BASIC CLEANING AND DISINFECTION PROTOCOL



The cleaning and disinfection of premises, equipment, vehicles, and personnel will be necessary to prevent the spread of animal pathogens during an animal health emergency. The C&D processes should be carried out in a systematic manner to ensure efficacy and efficiency. Regardless of the situation, item, or area, effective C&D involves understanding the steps of the basic C&D protocol (diagram to the right) – Cleaning: dry clean, wash, rinse and dry, and Disinfection: application, contact time, rinse and dry. All C&D personnel should understand this protocol, as well as the factors that may influence disinfection efficacy and any safety issues involved with C&D procedures.

4.1 Cleaning

Cleaning is one of the most important steps in the C&D process. When done appropriately, cleaning alone can remove over 90% of microorganisms. This step also helps improve disinfection efficacy since most disinfectants have reduced effectiveness in the presence of organic material. The cleaning process should be conducted prior to the application of **all** EPA-registered disinfectants. The cleaning process involves dry cleaning, then washing, followed by rinsing, and when possible, complete drying.

4.1.1 Dry Cleaning

Dry cleaning involves the removal of any gross contamination and organic material (e.g., soil, manure, bedding, feed) from production areas or equipment.

Shovels, manure forks, brooms, and brushes should be used to sweep, scrape, and remove organic material and debris from surfaces. In situations involving highly contagious foreign animal diseases (FAD), moistening the area or item with water may be helpful for controlling dust and minimizing aerosolization of pathogens. Bins may aid in transport of material to the disposal area. Heavy equipment such as bobcats or tractors may be needed to remove large quantities of manure and bedding. Air blowers should not be used for dry cleaning due to the risk of spreading pathogens.

Disposal of all material should be in a manner that minimizes further spread of microorganisms and that is compliant with federal, state, and local requirements and policies. In highly contagious disease situations, this may involve the burning, burial, or composting of material. Items that are difficult to clean or are of limited financial value (e.g., wooden gates or bunks, ropes, halters) should be appraised and disposed.

This process may require considerable time and effort, depending on the size and type of facility, but it is essential as this material can harbor microorganisms and reduce the efficacy or inactivate some disinfectants. Surfaces may not necessarily be visibly clean when this step is complete due to organic matter that adheres to the surface.

4.1.2 Washing

Following the removal of gross contamination (dry cleaning), areas or items should be washed with detergent. The washing process helps to further reduce the number of microorganisms as well as

removing any oil, grease, or exudates that may inhibit the action of disinfection. Washing prior to disinfection is one of the most commonly overlooked steps in the C&D process.

Prior to washing, all electrical equipment should be turned off and removed, or covered tightly with plastic sheeting. An electrician may need to be contacted for the removal of thermostats, timing devices, motor controls, and remote sensing equipment prior to washing. An alternative power supply (e.g., adjacent building, portable generator) may be needed to power electrical washing equipment. Some situations will involve specialized equipment (e.g., milk parlor cleaning) and will require extreme care. The owner may be able to assist with this operation to prevent damage to equipment.

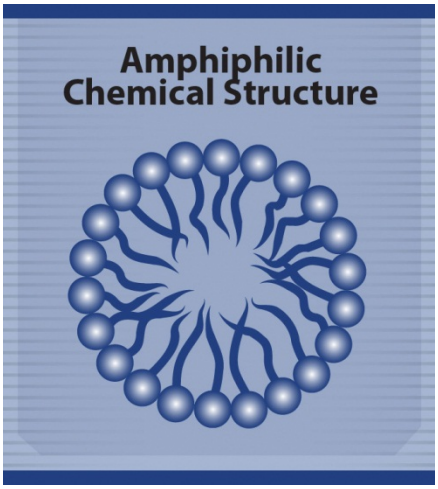
Areas and items with organic material adhered to the surfaces should be pre-soaked for several hours. Soaps or detergents can help disperse and remove organic material; however, the cleaning product used must be compatible with the disinfectant selected. Some disinfectant products may be formulated with a detergent component. Washing with a cleaner or detergent is required for any disinfectants that do not contain these components (e.g., are not registered as "one-step" disinfectants.)

Mechanical scrubbing and scraping (e.g., brushes) may be necessary to remove oils, grease, or exudates. Rough surfaces should be scrubbed with a wire brush to ensure that they are as clean as possible. Deep cracks, crevices, pits, pores, or other surface irregularities should be given special attention to dislodge accumulated grime.

High pressure water and detergent is very effective in removing the heavy accumulation of urine and feces often present in the environment and for cleaning porous surfaces. However, in cases of highly infectious or zoonotic pathogens, high pressure systems should be avoided or used with caution to avoid further dispersal of the pathogen or risk to the applicator.

Whenever possible, warm to hot water (90-130°F [32-54°C] or higher) should be used. This can increase efficacy for some products and may be important for the proper dissolution of certain chemicals (e.g., sodium carbonate). Heat may also aid in inactivating some pathogens. Hot water and steam can be effective for cleaning cracks, crevices, and the inside of pipes where pathogens are likely to linger.

4.1.2.1 Soaps and Detergents



Soaps and detergents are cleaning agents. As surfactants (surface-active agents) their chemical structure is amphiphilic and consists of a hydrophilic (polar head) and lipophilic (nonpolar tail) portion. This gives the solution both water-soluble and oil-soluble properties, serving to reduce surface tension and increase the penetrating ability of water to disperse, and removes organic material, dirt, and grease from surfaces. This surfactant action of soaps and detergents can also aid in inactivating bacteria and disrupting the lipid envelope of some viruses.

Detergents are classified based on their chemical structure.

- Anionic products (e.g., soaps, sodium lauryl sulfate) are the largest group and are negatively charged alkaline salts of fatty acids. They are strong detergents but weak disinfectants. They can be excessively foamy, leading to residue buildup that allows soil and microorganisms to accumulate, so they may be less ideal for some situations. However, anionic detergents do not complex with hard water metallic ions.
- Nonionic detergents are uncharged products that are very good emulsifiers with good penetration and reduced foaming properties. They have very little disinfection activity.
- Cationic products are positively charged solutions with some degree of antimicrobial efficacy (e.g., bacteria, some enveloped viruses). However, with the exception of quaternary ammonium compounds, these products are seldom used as cleaning ingredients.
- Amphoteric detergents combine the detergent qualities of anionic products with the bacteriostatic properties of cationic products. These products can have bactericidal activity over a wide pH range.

4.1.3 Rinse and Dry

After washing, all surfaces should be thoroughly rinsed, as residues from cleaners and detergent can inactivate certain chemical disinfectants. Rinsing should be done at low pressure with cold water. When the rinsing process is completed, surfaces should be carefully inspected to ensure they are visibly clean. Moisture should spread evenly over surfaces and no "beading" should occur, as this would indicate the presence of oil or grease. Rewash any areas that may require further attention in order to pass inspection.

Whenever possible, surfaces should be allowed to dry completely (if possible overnight) before application of a disinfectant. Excess moisture, especially on porous surfaces, may dilute and reduce the efficacy of the disinfectant applied to the surface; it may also harm equipment. In cool or cold weather, drying can be accomplished by heating the building and circulating the air with auxiliary blowers. In hot weather, drying may be accomplished with blowers or fans. In confined areas or on equipment where air circulation from fans is not enough, the use of high pressure air from a compressor or high volume blowers can aid in the removal of excess moisture so drying can take place. If highly infectious or zoonotic pathogens are suspected, high-pressure systems should be avoided or used with caution to avoid inadvertent spread of pathogens.

4.2 Disinfection

Disinfection methods can consist of physical (e.g., heat, ultraviolet light) or chemical (e.g., disinfectant) means. A combination of methods may be needed.

4.2.1. Application

Once surfaces are completely cleaned, rinsed, and dried, application of an appropriate disinfection measure can proceed. Application methods may involve spraying, fogging or misting, immersing or wiping or mop-on methods. Because products differ in formulation, the directions for use also differ. The specific manufacturer's instructions for effective use of a disinfectant should be followed. Appropriate safety measures (e.g., personal protective equipment) should be taken when implementing disinfection processes.

4.2.2. Contact Time

Regardless of the disinfection method chosen, one of the most important components of the procedure is to allow adequate contact time for the process to have its impact. In some cases, the chemical disinfectant may need to be reapplied to keep the surface wet for the required contact time.

4.2.3. Rinse and Dry

Following the application (and subsequent contact time) of chemical disinfectants, items and areas should be thoroughly rinsed. Most chemical disinfectants can be harmful to animals and should be rinsed with potable water and surfaces should be allowed to air dry prior to restocking of the area.

4.3 Downtime

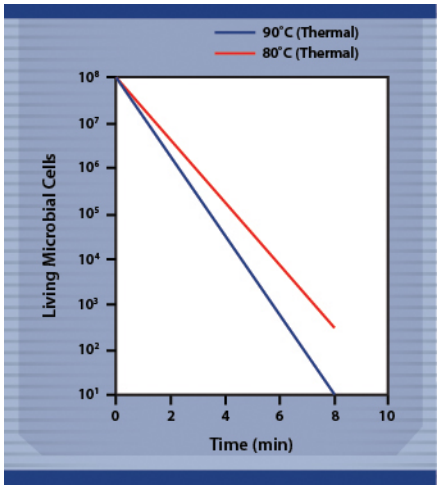
Premises that have been cleaned and disinfected should also have a period of downtime following the procedures. This involves the area remaining free of any animals or activity for a period of time to allow it to completely dry. The application of disinfectant solutions uniformly over large areas (e.g., ceilings, walls, floors) can be very difficult. Adequate downtime serves to further reduce or eliminate any remaining microorganisms on the premises through desiccation. Downtime can begin as soon as the premises is certified as clean and disinfected and should be at least three times the longest expected incubation time of the targeted pathogen. These areas should be cordoned off and designated with marking tape.

5. DISINFECTION METHODS

5.1 Physical Disinfection

While a number of physical disinfection processes are available, this section addresses those applicable to field conditions, which include, heat and radiation. Filtration, which does not kill microorganisms, is still discussed, as it can aid in the removal of microorganisms.

5.1.1 Heat



The thermal inactivation of infectious agents is one of the oldest and most widely used methods of disinfection. Heat destroys microorganisms by causing DNA disruption (breaks), protein denaturation, oxidative damage, and loss of membrane integrity. Infectious agents vary widely in their susceptibility to thermal inactivation. The process is gradual with microbial death occurring at a constant logarithmic rate of inactivation per unit of time. The time required is inversely related to the temperature and directly related to the number of microorganisms.

Heat can be applied under moist (e.g., autoclave, steam) or dry (e.g., flame, baking) conditions. Moist heat can be effectively applied through steam, boiling, or pasteurization. Steam under pressure (e.g., autoclaving) is the most efficient since it can achieve temperatures above the boiling point of water, which may be necessary when dealing with thermally resistant bacterial spores. Dry heat applications involve incineration (i.e., flaming) or hot air (i.e., baking). It can be useful for the disinfection of heat- resistant materials, such as glass or metals. Moist heat applications are generally more effective and require less time than dry heat.

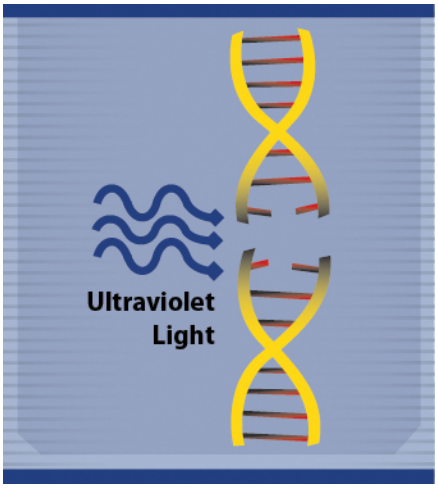
Most vegetative bacteria are inactivated at moist-heat temperatures of 131-149^{o}F (55-65^{o}C). Rapid destruction can occur at higher temperatures (e.g., less than 20 seconds at 161^{o}F [72^{o}C] or within seconds at temperatures above 176^{o}F [80^{o}C]). Many viruses are labile at temperatures close to 158^{o}F (70^{o}C). Bacterial endospores (e.g. *Bacillus anthracis* or *Clostridium botulinum* spores) are exceptionally thermostable and require temperatures of 250^{o}F (121^{o}C) or more for at least 15 minutes for destruction. Prions, such as those that cause BSE and scrapie, exhibit exceptional thermal stability. Disinfection methods for these pathogens will be discussed later.

Pasteurization involves the application of heat to food or liquid items (e.g., milk, cheese). It consists of heating to a temperature of 145°F (63°C) for 30 minutes, followed by rapid cooling (which helps prevent spore development). This process is considered a mild disinfection process as it does not kill all microorganisms. Pasteurization may be needed during an animal health emergency situation prior to dumping of milk from affected animals.

Cold temperatures (e.g., chilling or freezing) are not a reliable method of disinfection or sterilization. Cold temperatures (<50 °F [10°C]) can have bacteriostatic effects. Repeated freeze-thaw cycles can be destructive to microorganisms due to the damage or lysis of cell walls, membrane damage, or inactivation of proteins due to ice crystal formation.

5.1.2 Ultraviolet Radiation

The use of radiation to kill microorganisms in the field typically involves non-ionizing (e.g., ultraviolet light) methods. This form of radiation is low energy but has appreciable bactericidal activity and can be used as a supplemental disinfection method in clean areas.



Ultraviolet (UV) light is found in sunlight or generated by mercury vapor lamps. The most effective biocidal wavelength is in the 245 to 285 nanometer range. UV radiation inactivates organisms though a photochemical reaction that alters the molecular components essential to cell function (e.g., nucleic acids). The result is damage to cellular DNA and decomposition and internal rearrangement of microorganisms. Bacterial spores will require 10 times the exposure time as the vegetative forms of the organisms.

Ultraviolet light produces primarily a surface effect and does not penetrate even a thin layer of protein or pigment; organisms contained in organic matter or in cracks and crevices may be shielded or protected from the incident beam. Ultraviolet radiation may be useful for the control of airborne pathogens in enclosed areas. This method has also been used for water disinfection (i.e., aquaculture facilities); however, the water layers exposed to the light must be very thin. Humans and animals should not be exposed to high levels of UV light due to the potential for damage to the skin or eyes.

5.1.3 Filtration

Filtration, while not a disinfection method, can be used to physically remove microorganisms from gasses and fluids. Membrane filters consist of porous disks of biologically inert material that prevents or retards the passage of microorganisms based on their size. High efficiency particulate air (HEPA) filters are microfilters (≥0.3µm) that may be used to filter the air and to assure the safety of air discharged.

5.2 Chemical Disinfectants: Overview

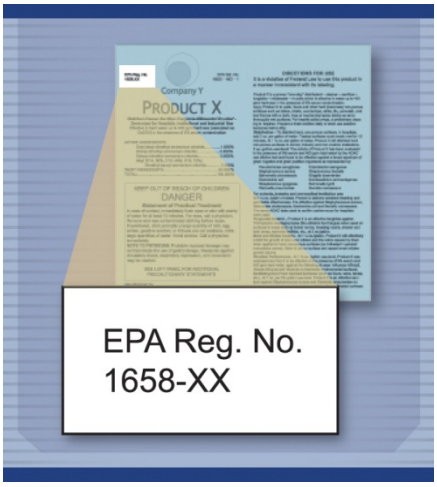
Chemical disinfectants inactivate a wide variety of microorganisms. The products may be classified by their chemical nature. Each class has unique characteristics, efficacy, and hazards. An ideal disinfectant is one that is broad spectrum, has low toxicity to humans and animals, is non-corrosive, and is relatively inexpensive. Few products meet all of these criteria; therefore, disinfection selection involves consideration of the product's spectrum of microorganism, material compatibility characteristics, and human hazards - all of which can usually be found on the product's label.

Most chemical disinfectants work by causing damage to a microorganism's outermost structural integrity (i.e., disruption of the membrane proteins and lipids) which results in altered function, lysis, or interference with active transport and energy metabolism. Chemical disinfectants readily inactivate most vegetative bacteria and enveloped viruses, while fungal spores and non-enveloped viruses are generally less susceptible. Mycobacteria, bacterial endospores, and protozoal oocysts are highly resistant to most disinfectants. Prions, the etiologic agents of bovine spongiform encephalopathy and scrapie, are exceptionally resistant to chemical inactivation.

5.3 Chemical Disinfectants: Regulation

5.3.1 U.S. Environmental Protection Agency

Chemical disinfectants in the United States are regulated by the U.S. Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) [Title 40 of the Code of Federal Regulations (CFR), Parts 150 to 189]. Under FIFRA, chemical disinfectants are considered to be "antimicrobial pesticides" that are intended for the control, prevention, and destruction of pathogenic microorganisms on inanimate objects and surfaces.



Prior to product registration and marketing, manufacturers are required to submit product chemistry, efficacy, and toxicity data along with proposed labeling for EPA's review. FIFRA requires that any pesticide be registered or exempted before it may be sold or distributed in the United States. A federally registered product registration number consists of two parts—the federal registrant's company number and the product number. [Note: Supplemental or distributor products bear three numbers – the federal registrant's company number, the product number, and the distributor's company number.] The product label for any EPA-registered disinfectant may be retrieved by entering the registration number in the EPA's Pesticide Product Label System (PPLS) search engine at http://oaspub.epa.gov/pestlabl/ppls.home.

FIFRA further requires that all label use directions and safety precautions must be followed. Application of a registered disinfectant in a manner inconsistent with its labeling may not only result in an ineffective application, but may be a "misuse" of the product and subject to potential enforcement action. Thus, a chemical disinfectant should be selected not only on the basis of its desirable characteristics, but also on whether it is registered or exempted under FIFRA, and whether it can be used in accordance with its label safety precautions and use directions for its intended use(s). Individual States may also have regulations which may be stricter than EPA's regulations.

The EPA Antimicrobials Division has a web site with information about the registration process, data requirements, labeling requirements, and other issues pertaining to chemical disinfectants at http://www2.epa.gov/pesticide-registration/antimicrobial-pesticide-registration.

5.3.2 Emergency Exemptions

In some situations (e.g., highly contagious foreign animal diseases), a particular pathogen may not be listed on the product label of an EPA-registered disinfectant. In these cases, Section 18 of FIFRA authorizes EPA to grant several different kinds of exemptions to Federal Agencies or States to use unregistered pesticides for a limited time, if EPA determines that emergency conditions exist. If granted, such exemptions would allow the use of non-registered pesticides or the "off-label" uses of a registered pesticide for a specified time period. Use is only allowed for designated personnel and as described in the exemption. A full explanation of FIFRA Section 18 exemption process can be found at http://www2.epa.gov/pesticide-registration/pesticide-emergency-exemptions.

Federal regulations regarding emergency exemptions are provided in the Code of Federal Regulations (40 CFR Part 166) at http://www.ecfr.gov/ [Select Title 40, then Parts 150-189, then Part 166: Exemption of Federal and State agencies for use of pesticides under emergency conditions]

5.3.3 U.S. Department of Agriculture, Animal and Plant Health Inspection Service

USDA-APHIS recommends that the selection of the disinfectant and disinfection methodology should be made from available U.S. EPA registered antimicrobial pesticide products (i.e., disinfectants). These products will either have been registered under FIFRA Section 3 (i.e., a regular label) or exempted under FIFRA Section 18 (i.e., emergency use label). These disinfectants should be used according to their approved labels following the indicated dilution, use sites, application method, contact time, precautionary statements, etc., against the pathogens specified on the label.

APHIS Directive 6901.1 (Registration, Use Management, and Coordination of Pesticides- 09/30/05) defines the APHIS policy regarding the safe and proper use of pesticides for purposes related to APHIS program delivery systems. http://www.aphis.usda.gov/library/directives/pdf/APHIS_6901_1.pdf

A registered disinfectant may also be used according to label directions against pathogens not listed on the label [see FIFRA Section 2(e)(e)] provided that this use is not in conflict with State or local regulations. The non-label-listed pathogens should be equally or more sensitive to inactivation by the disinfectant than the hardiest pathogen listed on the registered label.

USDA-APHIS VS Staff will collaborate with the APHIS Policy and Program Development (PPD) Environmental and Risk Analysis Services (ERAS) Staff to obtain exemptions from EPA, either in advance of or immediately after an animal health emergency, as needed. PPD ERAS will serve as the primary liaison for VS with EPA on all administrative matters pertaining to exemption registrations, renewals, amendments, and reporting.

Appendix C lists those disinfectants approved by EPA (under FIFRA Section 18) for use by USDA-APHIS against the causative agents of select foreign animal diseases.

An extensive list of EPA-approved pesticides to use against the causative agents of selected foreign animal diseases in farm settings can be found at http://www.aphis.usda.gov/animal_health/emergency_management/downloads/fad_epa_disinfectants.pdf.

5.4 Chemical Disinfectants: Classifications

The major classes of disinfectants used for animal health emergencies are described below (listed alphabetically). In the event of a highly contagious foreign animal disease outbreak, USDA-APHIS management will provide specific guidance to field personnel about which disinfectants should be used. A table summarizing the susceptibility of microorganisms to chemical disinfectant classes can be found in Appendix D.

Disclaimer: These descriptions provide generalized characteristics of chemical disinfectant classes. The efficacy of individual products may vary based on formulation. The use of trade names does not in any way signify endorsement of a particular product; they are only provided as examples. For additional product names, consult The National Pesticide Information Retrieval System (NIPRS) – a collection of pesticide-related databases available by subscription. See http://npirspublic.ceris.purdue.edu/public.html.

5.4.1 Acids

Acidic disinfectants include inorganic (e.g., hydrochloric acid, sulfuric acid) and organic (e.g., acetic acid, citric acid) compounds and exert antimicrobial action through the dissociation of free hydrogen ions, which alters the pH of the microorganism's environment. Some acids are EPA-registered as pesticides or exempted under FIFRA, while others are not.

Acids are generally effective against vegetative bacteria; the hydrogen ion is bacteriostatic in the pH range of 3 to 6 and bactericidal when the pH drops below 3. Many viruses (e.g., enveloped) are particularly sensitive to extremes of pH. Acids are not considered effective against *Mycobacteria* or non-enveloped viruses; however, foot-and-mouth disease virus is an exception and is particularly sensitive to acids. The efficacy of acids against bacterial spores is variable and limited, and often requires high concentrations. A 2.5% hydrochloric acid solution is a reasonably effective sporicide that has been used to disinfect animal hides potentially contaminated with anthrax spores before tanning.

Strong inorganic acids (e.g., hydrochloric acid, sulfuric acid) have been used to disinfect farm buildings, but are typically too hazardous for use as a disinfectant. Citric acid has been used alone or as an additive to detergents in other countries to inactivate the foot-and-mouth disease (FMD) virus. In October 2012, the EPA amended (under a FIFRA quarantine exemption) the use of citric acid to control FMD and African swine fever in the U.S. (http://www.aphis.usda.gov/animal_health/emergency_management/downloads/citric_acid_sec18_authorization_amendment.pdf). Acetic acid has been routinely used by the USDA (under a FIFRA quarantine exemption) to wipe down the coats of horses arriving from FMD virus positive countries. [Note: Household vinegar is a 4-5% b/v solution of acetic acid]. Some acidic compounds (e.g., formic, citric, lactic, malic, glutaric, and propionic acids) are added to anionic detergent or other disinfectant formulations to enhance antimicrobial properties.

Acidic disinfectants can be hazardous to personnel; high concentrations may be caustic and cause chemical burns. If acidic disinfectants are used, personnel should wear eye protection and rubber gloves during mixing, application, and rinsing. During preparation, the acid disinfectant should always be added to water (not the water to the acid). Acids are highly corrosive to metal surfaces (e.g., galvanized) and concrete. Acids have a defined but limited use in animal health emergency situations.

5.4.2 Alcohols

The most commonly used alcohol-based disinfectants are ethyl alcohol (ethanol) and isopropyl alcohol (isopropanol). Some alcohols are EPA-registered as “antimicrobial pesticides” under FIFRA, while others are not. Alcohols are rapidly acting broad-spectrum disinfectants. The hydroxyl functional group of the product interacts with the membrane proteins and lipids of the microorganism resulting in disorganization, membrane damage, and lysis. Alcohols are effective against vegetative and acid-fast bacteria, and enveloped viruses; fungi can be susceptible at prolonged contact times. Small, non-enveloped viruses may be resistant, but may be inactivated by higher alcohol concentrations. Alcohols are not sporicidal, but alcohol may potentiate the sporicidal effect of some halogen-based products (e.g., iodines).

Alcohols are most commonly used for hand sanitizers and antiseptics. The presence of water is necessary for alcohol efficacy; therefore, concentrations of 60-90% are recommended. [Most rubbing alcohol is 70%; hand sanitizers are typically 62%]. The effectiveness of alcohol disinfectants is limited in the presence of organic matter, and they do not have any residual activity. Alcohols may be used to disinfect small areas or items (e.g., pagers, cell phones, stethoscopes); however, alcohols can harden rubber and certain plastics after prolonged and repeated use. Alcohols may be used for surface disinfection; however, they evaporate rapidly making extended exposure time difficult.

Alcohols can also be highly flammable, so they must be stored in a cool, well-ventilated area and used with caution. They have been used in formulation combinations with phenols, quaternary ammonium compounds and chlorhexidine.

5.4.3 Aldehydes

Aldehyde [R-CHO] disinfectants include formaldehyde and glutaraldehyde. These alkylating agents denature proteins and disrupt nucleic acids causing irreversible inhibition of enzyme activity. Aldehyde

disinfectants are slow-acting but very effective against bacteria and enveloped viruses and somewhat effective against non-enveloped viruses, bacterial spores, and acid-fast bacteria. High concentrations of formaldehyde can destroy all microorganisms, including spores, and has been used extensively to inactivate viruses.

Aldehydes are generally non-corrosive to metals, rubber, plastic and cement, but are highly irritating and toxic to animals and humans via contact or inhalation. Appropriate personal protective equipment, (e.g., gloves, gowns, and face and eye protection) must be worn when using all aldehyde products.

Formaldehyde [H-CHO] can exist as a gas or liquid. While several liquid formaldehyde products are EPA-registered, no paraformaldehyde products are registered for producing formaldehyde gas. Only the USDA and the United States Army Medical Research Institute for Infectious Diseases (USAMRIID) have quarantine exemptions for use of paraformaldehyde to fumigate laboratories with formaldehyde gas. When permitted under an exemption, gaseous formaldehyde may be used to decontaminate air spaces and equipment that must be kept dry (e.g., electronic devices or equipment). The gas is also freely soluble in water and is used to generate an aqueous solution (formalin). [Note: 40% formaldehyde gas dissolved in water constitutes a 100% solution of formalin]. A solution of 4-8% formaldehyde in water is considered an intermediate to high-level disinfectant. It has been used to decontaminate rooms, buildings and instruments as well as poultry houses, hatching eggs, and hatchery equipment.

Formaldehyde combines readily with proteins, so efficacy is decreased by the presence of organic matter. Environmental conditions also affect efficacy, with optimum conditions being 70% relative humidity and a temperature around 57°F (14°C). Formaldehyde is acutely toxic to humans and has been identified as a potential carcinogen. Fumigation measures require specialized equipment and training. The pungent fumes can be irritating to mucous membranes, contact can cause skin irritation, and ingestion can be fatal. Personal protective equipment must always be worn when working with this compound, and application must be confined to areas which are air-tight and completely sealed to prevent gas escape. Occupational Safety and Health Administration (OSHA) standards limit the exposure time for personnel working with formaldehyde (29 CFR 1910.1048) and can be found at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10075&p_table=STANDARDS).

Glutaraldehyde is EPA-registered as a disinfectant in over 50 products at various concentrations. It has been used to disinfect medical equipment but can also act as a sterilant with a prolonged contact time. The efficacy of glutaraldehyde is affected by pH and temperature. While the product remains chemically stable at acidic pH levels, it is more "active" at alkaline (pH 7 or greater) levels. However, pH over 9 can result in decomposition of the product. Efficacy is also increased by greater temperatures. Compared to formaldehyde, glutaraldehyde can be more efficacious in the presence of organic matter, soaps, and hard water. Although it can be less acutely toxic than formaldehyde, exposure can cause acute and chronic skin and mucous membrane irritation, epistaxis, and possibly asthma. Glutaraldehyde is considered noncorrosive and usually does not damage rubber or plastics; however, it may be mildly corrosive to metals.

5.4.4 Alkalis

Alkali agents include products such as sodium or calcium hydroxide, sodium carbonate, and calcium oxide. Their antimicrobial action involves the dissociation of hydroxyl ions (–OH), which alters the environmental pH. These products also have saponifying (soap) action on fats and the lipid envelope of the outermost membrane, which also contributes to the cleaning process. The activity of these products is optimum at pH greater than 9; however, a pH above 12.0 may be needed for resistant bacterial pathogens (e.g., *Mycobacterium*). The activity of alkalis is slow, but can be increased by raising the temperature. Alkalis have good microbicidal properties, especially at high concentrations and at high temperatures. They are often used to disinfect livestock- or poultry-production areas, including pens, yards, buildings, and effluent waste pits and sewage collection areas, and maintain their effectiveness even with high concentrations of organic matter.

Alkalis are very caustic. Personal protective equipment (e.g., rubber gloves, boots, raincoat or apron, goggles) is essential when preparing or applying any of these agents. Exposure can cause severe skin burns. Dust from these products may cause severe burning of the eyes and mucous membranes or respiratory tract if inhaled. They can also cause burns on the footpads of animals and hoof drying and cracking. Alkalis are very corrosive to metals (especially aluminum) and painted or varnished surfaces; they will not harm bare wood.

Sodium hydroxide [NaOH] (i.e., lye, caustic soda) is a commonly used disinfecting alkali which has been applied extensively for cleaning and disinfection in various industries (e.g., slaughter houses, dairy industry). However, only two products are registered by EPA and neither is for agricultural uses. Only USDA-APHIS has an exemption for use of this chemical to inactivate foreign animal disease agents (see Appendix C), so only USDA personnel may use it as follows. For general disinfection, a working solution of 2% is sufficient for most disinfectant uses; it is most active in hot or boiling water. Higher concentrations are needed for sporicidal action, but use at these levels would require additional exemption approval from EPA. Sodium hydroxide is extremely caustic and must be used with great care. **Sodium hydroxide solution should ALWAYS be prepared by adding the lye to water.** Never pour water into lye, as a violent chemical reaction can occur, and high heat will be generated (which can melt plastic containers). Sodium hydroxide is corrosive to metals, especially aluminum and derived alloys.

Sodium carbonate [Na_2CO_3] (i.e., soda ash, washing soda) is a very good cleaning agent, but lacks efficacy against some bacteria and most viruses. Only four products containing this active ingredient are EPA-registered, and the maximum concentration of active ingredient in one product is 3%. Only USDA-APHIS has an exemption for use of this chemical to inactivate FAD agents (see Appendix C), so only USDA personnel may use it as follows. The anhydrous form is called soda ash, while hydrated sodium carbonate is often referred to as washing or sal soda. A 4% weight/volume (w/v) solution (1 lb/3 gal [0.454 kg/11.4 L] of water) has been used for washing vehicles and is currently used for cleaning the hooves of horses being imported into the United States. Sodium carbonate has poor activity in the presence of organic material and can be deactivated by hard water. This product can cause irritation during application and is harmful to aquatic life.

Calcium oxide [CaO] (i.e., quicklime) when mixed with water becomes lime wash and is sometimes used to retard putrefaction of buried carcasses after depopulation efforts. It has biocidal effects on some bacteria and viruses. However, only one product containing calcium oxide is EPA-registered, and that is for treatment of medical wastes.

Calcium hydroxide [CaOH] (i.e., air-slaked lime) is reasonably effective against many non-spore-forming organisms. No end-use products containing calcium hydroxide are currently EPA-registered, so the following uses are not registered at this time. When mixed with water, it forms hydroxyl ions (–OH) and liberates heat [$CaO + H_2O = Ca(OH)_2 + HEAT$]. Although it is not sporicidal, it has been used to disinfect premises. A 20% suspension is commonly used as whitewash.

Note: Quicklime (calcium oxide) is produced by burning limestone. If water is added to quicklime, slaked lime is produced. If lime is exposed to the air, air-slaked lime (calcium hydroxide) is formed.

5.4.5 Biguanides

Biguanides are cationic compounds often used as a skin antiseptic and for preoperative skin preparation. It has also been used as an effective cattle teat dip. Chlorhexidine is one of the most widely used biguanides and has very effective bactericidal action, but some bacteria (e.g., *Pseudomonas*) may be resistant. Two chlorhexidine products are EPA-registered for use on farm premises. It is not mycobactericidal or sporicidal and has variable efficacy against fungi. Biguanides function by changing the cytoplasmic membrane permeability. These disinfectants are inactivated by anionic compounds (e.g.,

soaps and detergents), hard water and organic matter and are pH sensitive, only functioning in the range of pH 5-7. Biguanides are toxic to fish and should not be discharged into the environment.

5.4.6 Halogen Compounds

Halogen-based compounds include chlorine- or iodine-containing agents. They function through their electronegative nature to denature proteins. Antimicrobial efficacy is rapid but is related to the concentration of free chlorine or iodine available. Halogens are not affected by water hardness and are generally compatible with soaps and detergents. They are inactivated by UV light and some metals. Halogens, especially chlorine, should never be mixed with strong acids or ammonia as toxic gases can be formed. Halogens are extremely sensitive to organic material, so thorough cleaning must be done prior to application. When used on clean surfaces, halogen-based compounds are broad-spectrum, with efficacy against bacteria, most viruses, *Mycobacteria*, and fungi; they can be sporicidal at high concentrations. Halogen products can lose their potency over time or at high temperatures. They are generally low in cost and are relatively easy to use. Halogens are, however, highly toxic to aquatic animals, so discharge into watersheds or waterways must be avoided. If this is not possible, efforts should be taken to neutralize the halogen solution with sodium thiosulfate (5 moles sodium thiosulfate to 4 moles halogen).

Hypochlorites are one of the most widely used **chlorine-containing disinfectants**. They are sold in liquid form (e.g., sodium hypochlorite - household bleach) or as a solid (e.g., calcium hypochlorite - a swimming pool chemical). Regular strength household bleach is a 5.25-6% aqueous solution of sodium hypochlorite (52,500-60,000 ppm available chlorine). There are hundreds of EPA-registered antimicrobial pesticide products containing sodium or calcium hypochlorite as the active ingredient, although not for FAD agents. USDA-APHIS has a quarantine exemption for use of sodium hypochlorite for inactivating FAD agents. Sanitizing and disinfecting concentrations vary from 50 to 5,000 parts per million (ppm). Sodium hypochlorite diluted to 5,000-6,000 ppm (1:10 bleach: water ratio) and corrected to pH 7 through the addition of acetic acid can be an effective sporicide. This mixture has been used at anthrax clean-up sites under a crisis exemption. High concentrations of hypochlorites are irritating to the mucous membranes, eyes, and skin, and can cause damage to the footpads of animals. Chlorine-containing compounds are very corrosive to rubber, fabrics, and some metals; concentrated solutions can etch or erode concrete surfaces over time.

Iodine-containing compounds most commonly used for disinfection purposes are iodophors, complexes of iodine with a solubilizing agent which sustains release (slow) of free iodine. Povidone-iodine (i.e., polyvinylpyrrolidone) is one such example. Iodophors are broad-spectrum disinfectants, good for general use. They are bactericidal, mycobactericidal, and generally virucidal (may be less effective against non-enveloped viruses compared to chlorine-containing compounds). Several iodine-based disinfectants are EPA-registered. Iodine-containing solutions can be irritating to the skin and may also stain clothes and damage rubber and some metals.

5.4.7 Oxidizing Agents

Peroxide-based disinfectants are broad-spectrum and function by denaturing the proteins and lipids of microorganisms leading to membrane disorganization. Dilute oxidizing agents are considered effective on hard surfaces and equipment and are considered relatively low toxicity but may be irritating or damage clothing when concentrated.

Hydrogen peroxide [H_2O_2] is rapid acting. Solutions of 5-20% are considered bactericidal, virucidal (for enveloped viruses), fungicidal, and sporicidal (at the higher concentrations). Its effectiveness against non-enveloped viruses, spores, and acid-fast bacteria is questionable. Household (over-the-counter) hydrogen peroxide consists of a 3-10% solution; industrial concentration hydrogen peroxide is a 30% or greater solution. Over 100 antimicrobial pesticide products containing hydrogen peroxide are EPA-registered.

Hydrogen peroxide solutions can break down quickly, so fresh solutions should be used. Stabilizers are now being added to some commercial hydrogen peroxide products to minimize degradation after mixing.

Peracetic acid [$CH_3C(O)OOH$] (peroxyacetic acid) is a strong oxidizing agent effective in the presence of organic matter. It is considered effective against many microorganisms and is an effective sporicide. Over 50 antimicrobial pesticide products containing peracetic acid are EPA-registered. In its pure form, peracetic acid is extremely shock sensitive and explosive. Products supplied as a 40% solution in acetic acid have open cup flash point of 104°F (40.5°C) and will spontaneously explode when heated to 230° F (110°C). Modern stabilized products are generally mixtures of peracetic acid, hydrogen peroxide, and/or acetic acid, with the level of peracetic acid (active ingredient) generally 0.25% or less. Solutions may corrode soft metals such as copper or brass, as well as steel and galvanized iron. It can also react with natural and synthetic rubber, releasing potential carcinogens.

Peroxymonosulfate-based products are broad-spectrum products with some efficacy in the presence of organic material. The only EPA-registered product is Virkon® S, a buffered potassium peroxymonosulfate compound modified with the addition of surfactants and organic acids. The product is typically used at a 1% concentration solution which has a pH of 2.6, so should not be used on skin. In general, the product is considered to have low human toxicity; however, preparation of the powdered form can cause mucous membrane irritation. Face and eye protection should be worn. Virkon® S has been shown to be effective for direct misting of hard to reach surfaces and for footbath solutions. Prepared solutions are unstable once diluted, with a 1% solution degrading to half-strength in six days. Product ingredient decomposition and degradation are considered comparatively harmless to the environment. It can be corrosive to steel, iron and concrete.

5.4.8 Phenols

Phenols [C_6H_5OH] are among the oldest established disinfectants and include compounds derived from coal-tar or synthetic formulations or various homologues (e.g., cresols, xylenols and ethylphenols). These compounds can have a strong pine-tar odor and usually turn milky when added to water. They are generally broad-spectrum and function by denaturing cellular proteins, thereby disrupting cell wall permeability and causing molecular instability of microorganisms. The antimicrobial activity depends on the formulation, but phenolics are generally effective against many bacteria, *Mycobacteria,* fungi, and enveloped viruses. Their efficacy against non-enveloped viruses is variable, and they have minimal sporicidal activity.

Phenolics are often formulated with soap (anionic) solutions to enhance their penetrative power. Nonionic and cationic surfactants can reduce or destroy the activity of phenolic products. A commonly used phenol compound is orthophenylphenol. Over 90 antimicrobial pesticide products containing orthophenylphenol are EPA-registered. One of the substituted phenols, 2-phenylphenol, is particularly effective against *Mycobacterium* species which are normally quite refractory to disinfectants. It was extensively used during the campaign against *Mycobacterium bovis* in the United States. Phenols are stable at concentrated and use dilutions. They have a high tolerance of organic load and hard water. Some products may have residual activity after drying. Phenols are temperature sensitive and should be applied at a temperature of 60°F (15.6° C) or greater. If the environmental temperature is below 60°F, heating the solution to 120°F (49° C) or higher can help ensure proper temperature during necessary contact time.

Phenols are readily absorbed by porous materials, and can damage rubber and plastics. They are also readily absorbed through the skin and can cause severe burns at high concentrations. Skin and eye irritations have also occurred. Phenols are fatal if swallowed, and concentrations over 2% are highly toxic to all animals, especially cats (e.g., systemic toxicosis) and pigs (e.g., dermal contact lesions). Surfaces should be thoroughly rinsed prior to restocking of animals; however, there are environmental concerns when disposing of these compounds, so containment efforts may be warranted.

5.4.9 Quaternary Ammonium Compounds

Quaternary ammonium compounds (QAC) are a diverse group of cationic surfactants normally used for routine cleaning of noncritical surfaces. Hundreds of antimicrobial pesticide products containing QACs are EPA-registered. QACs function by irreversibly binding to the negatively charged phospholipids in bacterial cell membranes and denaturing membrane proteins impairing permeability. QACs are effective against many bacteria and are somewhat effective against fungi. They have limited effectiveness against enveloped viruses and are not generally mycobactericidal or virucidal for non-enveloped viruses; they are ineffective against spores. There are several "generations" of products that vary in composition and performance. Later generations are typically more germicidal, less foaming, more tolerant of organic loads, and more tolerant of anionic soaps and detergents. Some products may have a bacteriostatic residual effect. QACs are pH sensitive. They are more active at neutral to slightly basic pH but lose activity at pH less than 3.5; they can also have reduced activity in hard water conditions.

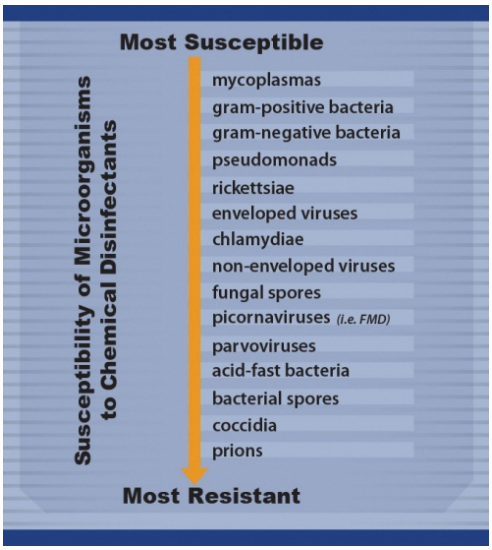
When used at recommended dilutions, QACs are generally non-toxic, but higher concentrations can be corrosive to metals and can cause irritation of the skin, eyes, and respiratory tract. Common QACs are alkyl dimethyl ammonium chloride, alkyl didecyl dimethyl ammonium chloride, and dialkyl dimethyl ammonium chloride; benzalkonium chloride is one of the most widely used.

6. DISINFECTION METHOD SELECTION AND CONSIDERATIONS

While C&D procedures appear to be straightforward, there are a number of factors to be considered when selecting a disinfection method or chemical product. These factors can impact efficacy, possibly cause failure of the disinfection procedures, or result in hazards or injury to personnel or animal if not considered or addressed; these include characteristics of the microorganism, disinfection methods and environmental factors.

6.1 Microorganism Considerations

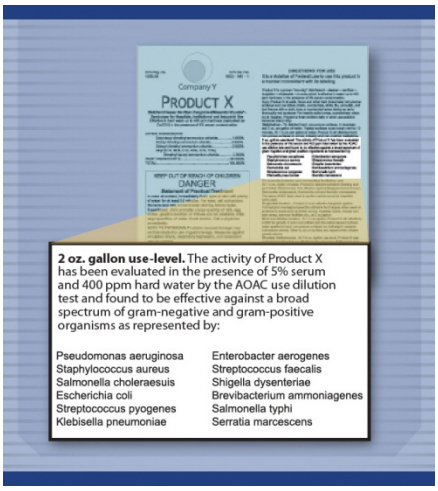
Microorganisms vary in their ability to survive or persist in the environment as well as their susceptibility to disinfection. It is important to be aware of the suspect or confirmed pathogen involved in order to select the most efficacious disinfection method. This will include understanding the general properties of the disease agent, its ability to persist in the environment, its transmission and its susceptibility to disinfection.



Most vegetative bacteria are readily inactivated by disinfectants, while *Mycobacteria* or bacterial endospores are more resistant. Virus susceptibility is generally related to the presence or absence of a lipid envelope. The lipophilic, enveloped viruses (e.g., coronaviruses, herpesviruses, orthomyxoviruses, paramyxoviruses, retroviruses) are generally more susceptible to disinfectants than the hydrophilic, non-enveloped viruses (e.g., adenoviruses, picornaviruses, reovirusess, rotaviruses), which can be quite resistant. Fungal spores are also quite resistant to many disinfectants. Prions, the etiologic agents of bovine spongiform encephalopathy and scrapie, are exceptionally resistant to chemical inactivation.

Appendix E lists several high consequence diseases and their microbiological classification.

6.2 Disinfectant Considerations



Chemical disinfectants are highly toxic to a wide variety of microbes; however, specific classes can have limited spectrums of efficacy against particular microorganisms. Appendix D provides a summary of the sensitivity of microorganisms to different categories of chemical disinfectants. Note: The effectiveness of a particular product is determined by its composition and the conditions under which it is applied.

6.2.1 Concentration

Using the proper concentration of a chemical disinfectant is important to achieve the best results for each situation. If the product is to be diluted, the label will provide specific mixing directions (e.g., X oz. of product per unit volume of water or other diluent) and will list the minimum concentration needed for a particular item or situation. Be sure to consider any standing water or other water sources (e.g., rainfall) in the area as potential dilution source for a disinfectant.

6.2.2 Application Method

There are a variety of ways to apply disinfectants, but only the methods described on the label may be used. The surfaces of objects or structures may be treated with a disinfectant solution by wiping, brushing, spraying or misting. Small portable items should be soaked in a container of disinfectant. Fumigation may be used in some situations for items that cannot get wet (e.g., electronics), but is inefficient in buildings with ill-fitting doors and windows, or damaged roofs. Insufficient amounts of disinfectant applied may not thoroughly cover and penetrate all surfaces and lead to ineffective efforts.

6.2.3 Contact Time

Contact time is essential and should be specified on the label of the product selected. Microbes in contact with disinfection products are inactivated or killed gradually, not instantaneously. Therefore, allowing adequate contact time will increase the efficacy of any disinfectant. Contact times may vary depending on the product or method used. Areas being disinfected should remain wet with the disinfectant during the necessary contact time. Reapplication of disinfectant may be necessary to achieve the product label-indicated contact time. Some disinfectants may evaporate quickly (i.e., alcohols), while others may have residual activity (i.e., phenols).

6.2.4 Stability and Storage

Some disinfectants (i.e., sodium hypochlorite) can lose stability quickly after being prepared for use or when stored over long periods, especially in the presence of heat or light. Disinfectant product labels may list the shelf life of the concentrated product. To maximize stability and shelf life, products should be stored in a dark, cool location and preferably in stock concentrations. Use of an outdated product may result in ineffective applications.

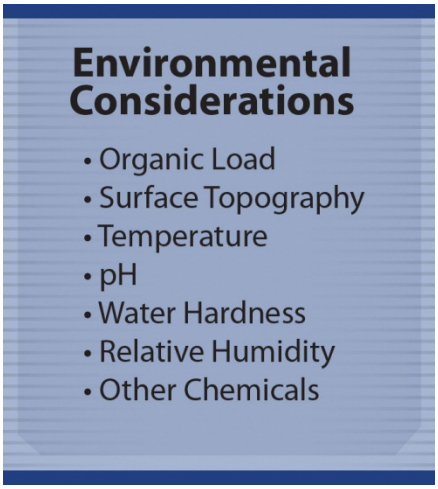
6.2.5 Safety Precautions

Most disinfectants can cause irritation to eyes, skin, and/or the respiratory tract; some may cause burns or other injury. The safety of all personnel must be paramount when handling, mixing, and applying chemical disinfectants. It is essential that C&D personnel are trained on the proper procedures and hazards of the products they will be using. Personal Protective Equipment (PPE), such as hand, face, and eye protection, should be worn during the mixing or application of disinfectants. All chemical disinfectants have a Material Safety Data Sheets (MSDS) listing the stability, hazards, and personal

protection needed, as well as first aid information. This information should be available to all personnel. A 3-ring binder containing this information in one easily accessible location may be useful.

6.3 Environmental Considerations

Environmental conditions such as organic load, surface topography, temperature, pH, water hardness, relative humidity, and the presence of other chemicals can also impact the efficacy of disinfection procedures.



6.3.1 Organic Load

Organic matter (i.e., soil, bedding, litter, feed, manure) provides a physical barrier that protects microorganisms from contact with the disinfectant. Ultraviolet light and sunlight have limited penetration below the surface of organic matter. Debris and organic material can also neutralize many disinfectants (especially chlorine and iodine containing compounds). Removal of all organic material prior to application of a disinfectant is essential. Some disinfectants may have some efficacy or residual activity in the presence of organic material (i.e., phenols) and should be considered in circumstances where complete removal of organic debris is difficult. However, application of these products to a heavy organic load (e.g., non-cleaned surfaces) may not be completely effective.

6.3.2 Surface Topography

An ideal surface to be disinfected is smooth; however, those encountered during an animal health emergency may consist of fabric or woven material (e.g., clothes, nets, and ropes), hard surfaces (e.g., plastic, cement, metal) or permeable materials (e.g., earth, gravel). Porous, uneven, cracked, or pitted surfaces, especially wooden surfaces and earthen floors, can hide microorganisms; and these surfaces are difficult to disinfect. Some chemical disinfectants may also be incompatible with or corrosive to certain materials or surface types.

It is important to note that all liquid chemical disinfectants are approved only for use on hard, non-porous surfaces, which means that they should not be applied to porous surfaces. Instead, gaseous or vaporous sterilant products (which are effective on both non-porous and porous surfaces) and/or physical disinfection methods (e.g., drying, ultraviolet light), should be used for treating porous surfaces.

6.3.3 Temperature

In general, most disinfectants work best at temperatures above 68^{o}F (20^{o}C). Elevated temperatures may aid in microorganism destruction; however, higher temperatures may also accelerate decomposition or evaporation of a disinfectant, thereby reducing the necessary contact time and efficacy. Heat may also damage items being disinfected. Low temperatures generally reduce the efficacy of chemical disinfectant products. Additionally, disinfectant solutions may freeze outdoors under low temperature conditions.

6.3.4. pH

The pH or hydrogen ion concentration of the environment can influence both the microorganism and the chemical agent. This effect can alter the charge on the outer surface of the microbe. The pH can also change the degree of ionization of a chemical disinfectant, thereby impacting efficacy. For example, the efficacy of glutaraldehyde is dependent on pH, working best at a pH greater than 7. In contrast, quaternary ammonium compounds have the greatest efficacy at a pH of 9-10. The pH can also affect the activity of phenolics, hypochlorite, and iodine compounds.

6.3.5 Water Hardness

The water source used when diluting and applying detergents and disinfectants is important. Water hardness can inactivate or reduce the effectiveness of certain disinfectants (i.e., quaternary ammonium compounds). Hard water contains calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions leached from limestone and other minerals as groundwater passes over it. These ions can complex with cleaning and disinfection products, leading to inactivation, reduced efficacy, or residue buildup.

6.3.6 Relative Humidity

Relative humidity is the ratio of water vapor in the air at a specific temperature compared to the maximum amount of water that the air could hold at that same temperature; it is a function of both moisture content and temperature of the environment. This is important since the activity of some chemical disinfectants is influenced by the relative humidity of the environment. For example, formaldehyde fumigation requires a relative humidity in excess of 70% for effectiveness.

6.3.7 Presence of Other Chemicals

Interaction with other chemical (e.g., soaps, detergents) or structural compositions (e.g., metals, rubber) can also affect a disinfectant's efficacy. Iodine agents are inactivated by quaternary ammonium compounds, while phenols are commonly formulated with soaps to increase their penetrative ability.

7. CLEANING AND DISINFECTION PROCEDURES

Cleaning and disinfection procedures require careful planning and coordination to ensure optimum reduction or elimination of the targeted pathogen on the infected premises, to prevent further movement of pathogens between premises, and to ensure the safety of response personnel, animals, and the environment.

7.1 Assessment

The first step for any effective disinfection procedure involves a thorough assessment of the situation. This includes identifying the target pathogen to be controlled or eliminated, determining the areas and items in need of disinfection, selecting the proper disinfection method or methods to be used (e.g., chemical or physical), and identifying and addressing any potential safety or hazardous issues that may occur.

7.2 Planning

Next, a site-specific C&D plan should be developed. This action plan should include a list of the specific actions needed (in chronological order) and the estimated time frame to perform the procedures. Protocols for disinfecting structures, pens, and equipment should be established. A process to certify and record C&D procedures will also need to be established.

The site-specific C&D plan should also address the details on how to dispose of materials (e.g., gross debris, chemical solutions) in a manner that minimizes the further spread of microorganisms and is compliant with federal, state, and local requirements and policies. Once the situation is thoroughly assessed, the necessary personnel, equipment and supplies can be determined, and any regulatory permits or approvals can be obtained.

For any incident, cleaning and disinfection measures should begin as soon as possible to minimize the transfer of pathogens by contaminated vehicles, equipment, and personnel or animals involved. Planning for situations such as disinfectant containment or runoff must also occur. Poorly planned or inadequate disinfection efforts can have disastrous consequences, especially when a highly contagious foreign animal disease agent is present. Responders should not enter contaminated areas until C&D stations are in place, manned, and equipped.

7.2.1 Personnel Requirements

The number of personnel required for a given situation will vary depending on the quantity and size of the areas and buildings, the sanitary conditions of the premises, and the time frame within which the work is to be performed. As an example, one or more C&D teams of 10 persons each is recommended for disinfecting large farms and stockyards or sale barns. All C&D team personnel, including any contractors used, must be trained on basic C&D procedures, safety protocols and issues, as well as the nature of the situation (e.g., highly contagious foreign animal disease or zoonotic disease) prior to initiating work.

7.2.2 C&D Equipment and Supplies

Equipment needs for C&D operations will also vary with the situation. Acquisition of equipment should be done in conjunction and coordination with the Logistic Section for the response, as obtaining some equipment may involve the use of contracts and leases with appropriate local officials or businesses. Large amounts of water will also be needed for C&D operations. Water mains or alternative water sources (wells, tankers) should be identified. Basic equipment needed for C&D operations are listed in Appendix F and described in the *FAD PReP SOP: Cleaning and Disinfection*.

7.2.3 Personal Protective Equipment

Personal Protective Equipment (PPE) for C&D team members will be needed. Many chemical disinfectants are hazardous to humans; therefore, chemical resistant gloves, and face and eye protection should be worn when mixing and applying solutions. Waterproof aprons or suits should also be worn when preparing disinfectant solutions. Additional information on PPE may be found in the *FAD PReP SOP: Cleaning and Disinfection* and the *FAD PReP/NAHEMS Guidelines: Personal Protective Equipment* .

7.3 Documentation

During C&D procedures, it will be necessary to maintain various types of documentation. Information on the materials used and expended, as well as the cost of such materials will be necessary for indemnity, reimbursement, or cost-sharing purposes. The costs associated may include labor charges and equipment rentals or purchases as well as expendable equipment or supplies or subcontractor costs. Information on personnel will also be needed and may include the number and identity of C&D team members.

Documentation will also be essential to tracking vehicles, heavy equipment, and people who exit and enter the area. Log sheets on the type, formulation, quantity, and date of preparation for chemical disinfectants will also be pertinent information to record. Written documentation can be maintained in a logbook format. Information should be recorded in ink, and anyone making entries into the logbook should sign and date the bottom of the entry page. Any entry errors should have a single line drawn through them with the author's initials and date. Pages should never be removed from a logbook.

7.4 C&D Stations

Cleaning and disinfection procedures should begin as soon as possible after assessment. However, some measures may need to be delayed until animals are removed (e.g., temporary housing, depopulation) from the premises or area. The level of disinfection required will depend on situation and pathogen involved. For most situations, C&D protocols to be established will include personnel stations, vehicle stations, and procedures for equipment and facilities.

7.4.1 Site Selection

The location used to establish C&D stations is critical and should be adjacent to or at the entrance points to an infected premises. This will provide easy access for responders and a centralized location for most procedures and serve as a visual indicator of the need to implement disinfection measures.

Stations established for C&D efforts will involve two scales: small scale for personnel and small equipment, and large scale (e.g., vehicles, heavy machinery).

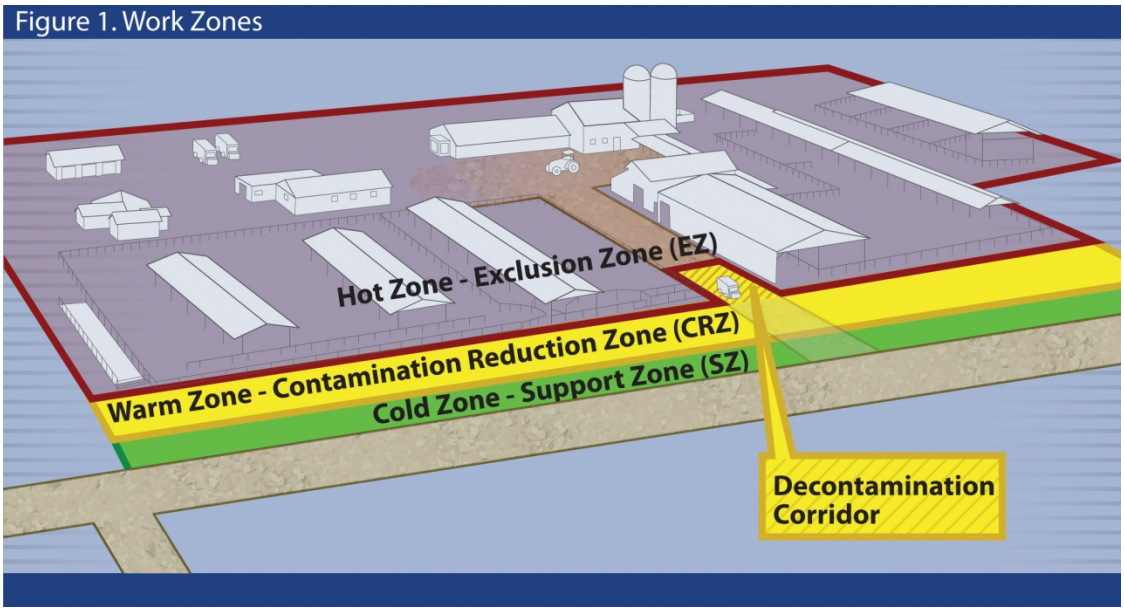
Stations should be established at areas with flat terrain, large enough to house the necessary C&D components (e.g., disinfection station, water supply, waste water containment). The site (and drainage from the location) should be located away from sensitive environmental areas, such as wetlands or well-head areas. When possible, C&D sites should be located near sources of potable water and sanitary sewers.

7.4.2 Station Design and Setup

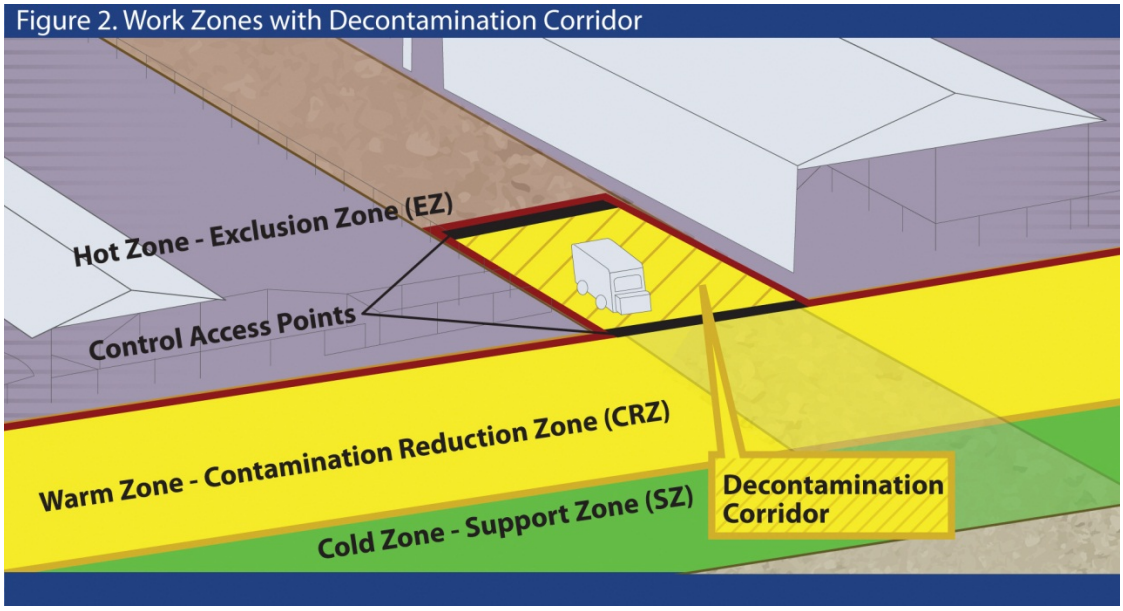
Once a location has been selected, movement through the station should follow basic decontamination staging protocols. Typically, three work zones and a corridor are established to help protect responders and prevent the accidental spread of the hazard (Figures 1 and 2). The three major work zones and corridor according to the *FAD PReP/NAHEMS Guidelines: Biosecurity* are listed below.

- **Hot Zone - Exclusion Zone (EZ):** This high-risk area is where infected animals were housed and is potentially contaminated and considered unsafe. Examples include an area of a farm, local market, or roadside stand. PPE must be worn. Appraisal, depopulation, disposal, and facility cleaning and decontamination of the site and equipment occur in this area. Personnel and equipment enter and exit the Hot Zone through designated access points in the Warm Zone - Contamination Reduction Zone (CRZ).
- **Warm Zone - Contamination Reduction Zone (CRZ):** This is a high risk area due to the potential of exposure to pathogens and chemical disinfectants. All personnel are required to wear full PPE. Entry from the Warm Zone - Contamination Reduction Zone (CRZ) to either the Cold Zone - Support Zone (SZ) or Hot Zone - Exclusion Zone (EZ) occurs through designated access points. For workers exiting the Hot Zone - Exclusion Zone (EZ), final decontamination and disinfection of PPE and equipment as well as final doffing of PPE occur in the Decontamination Corridor of the Warm Zone - Contamination Reduction Zone (CRZ). Site-specific protocols for PPE, decontamination and disinfection must be strictly followed.
- **Cold Zone - Support Zone (SZ):** This is the "cleanest" work zone with the lowest relative risk of exposure to pathogens and other hazards such as decontamination chemicals. In this zone personnel are not required to wear PPE; however, facilities for donning PPE before entering other zones are provided. Administrative, clerical and other support functions are based here. Medical support is provided to personnel in this zone. Facilities for personal needs such as eating, drinking and bathroom use are provided. Air and surface monitoring is conducted as needed to ensure that the area is free from contamination. Contaminated articles and equipment are prohibited in this area. Decontamination activities are also prohibited.

The size (i.e., width) of these zones will vary with the scale of activities required (e.g., room for vehicles versus personnel). The use of plastic tape can help in differentiating the various C&D zones.



- **Decon (Decontamination) Corridor:** The area between the Hot Zone - Exclusion Zone (EZ) Control Line and the Warm Zone - Contamination Reduction Zone (CRZ) Control Line. Decontamination of personnel and equipment occurs along the corridor with stations for depositing tools, equipment, protective clothing and other items. The level of contamination should decrease along this corridor from the Hot Zone - Exclusion Zone (EZ) to the Cold Zone - Support Zone (SZ). Teams enter and exit the Hot Zone - Exclusion Zone **(**EZ) through the access control points at each end of the corridor.



7.5 Disinfectant Preparation and Application

The preparation and application of disinfectant solutions must be in accordance with product label directions or the terms of the FIFRA Section 18 exemption. Only EPA-registered or approved (i.e., FIFRA Section 18 exemption) products should be used.

7.5.1 Preparation

Chemical disinfectants should be stored in a cool location to maximize shelf life, since some products can lose stability after prolonged storage. Check the product label for the expiration date.

Fresh solutions should be prepared immediately prior to use, since some disinfectant solutions may only remain active for short periods of time (e.g., same day of preparation). Failure to make fresh solutions may result in using a product that has reduced efficacy. The use of test kits can help to determine whether any chemical degradation of the disinfectant's active ingredients has occurred and whether diluted solutions contain the necessary amount of active ingredient.

The quantity of disinfectant solution needed for a given situation is determined by the total surface area to be covered (e.g., floor, ceiling, walls, fixed equipment). In general, one gallon of diluted disinfectant usually covers approximately 100-150 square feet of surface area.

7.5.2 Application

Application methods can vary (e.g., wiping, brushing, spraying, misting, immersion, fumigation) and should be conducted as recommended on the product label. Application should occur in a systematic manner (e.g., top to bottom, small sections) to ensure all areas are treated adequately. Ensuring the necessary contact time is essential and surfaces must remain wet with disinfectant solution during this process.

Disinfectants should not be applied directly to animals unless labeled for such use. Application around feeders, waterers, or animal contact areas should be done with caution and be followed by a thorough rinsing before animal reintroduction. During cold weather, buildings should be heated to approximately 68^{o}F (20^{o}C) since some disinfectants are less effective or ineffective at low temperatures.

Following application, pressure sprayers and pumps should be properly cleaned to remove potentially corrosive disinfectant solutions. Cleaning and disinfection supplies (e.g., towels, mops) should be treated as biohazardous waste and discarded or properly disinfected before removal from the premises.

7.6 Small-Scale Disinfection Stations [personnel, small equipment]

Responders working at sites of animal health emergencies will have exposure to disease-causing organisms. Measures must be taken to decontaminate individuals and their clothing, and to disinfect equipment or supplies used on the premises to minimize further spread of the pathogens and protect the individual. Personnel working in close contact with the infected animals or their by-products will have the greatest level of contamination.

Small-scale C&D stations should be set up on an impermeable surface (e.g., plastic sheeting) near the entrance/exit point of the infected or suspected premises using the three work zones previously described. This helps to prevent fluid infiltration into the soil while allowing containment of fluids and easier cleanup of the area following procedures.

If possible, a building or shelter with a water supply and drainage should be included. Runoff water should be contained and not allowed to drain into "clean" areas. The station should contain equipment (e.g., tubs, scrub brushes) to aid in the removal of gross debris and application of disinfection products.

7.6.1 Personal Protective Equipment

All personal protective equipment (PPE) worn during the response must be either disposed of or cleaned and disinfected prior to leaving the premise. When possible, disposable boots, gloves, and coveralls should be used. These items can then be placed in plastic garbage bags and sealed for disposal later in a designated manner.

Upon entering the Decontamination Corridor, waterproof or nylon coveralls should be scrubbed with detergent and rinsed to remove any gross debris. A disinfectant solution can then be applied via low-pressure spray or scrub brushes. Items may also be removed and soaked in a container of disinfectant solution, ensuring complete contact of the solution with all surfaces and allowing for the adequate contact time.

Footwear should be thoroughly cleaned (e.g., organic material removed) and rinsed prior to inserting these items into an EPA-registered or exempted disinfectant labeled for such use. The footwear must also remain for the necessary contact time (as per the product label) to ensure optimum efficacy. [Note: Disinfectant footbaths may give a false sense of security to responders and should not be used as a sole process of disinfection; however, the process will serve to raise awareness about the need for biosecurity and disinfection for the disease situation present].

Suggested respirator cleaning and sanitation procedures are available from the Occupational Safety and Health Administration (OSHA) at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9782.

7.6.2 Personnel

Individuals must thoroughly wash their hands with antibacterial soap before entering and leaving the premises. Warm water with antimicrobial soaps, scrubs, and hand cleaners should be available for personnel decontamination following removal of disinfected PPE items. Each person should have or be provided with a clean change of clothes (e.g., coveralls). Privacy (e.g., tent, metal shed, trailer with shower) for changing needs should also be provided when possible.

7.6.3 Emergency Medical Situations

During a response, incidents of serious injury or medical conditions may warrant the need for emergency transport of personnel out of an infectious area. Human life is a priority and every measure must be taken to minimize discomfort or pain. Disinfection procedures may require abbreviated measures in efforts to administer appropriate care and treatment. The need and level of disinfection prior to exit will depend on the seriousness of the injuries. However, the risk of disease transfer and spread should be addressed. At a minimum, emergency response vehicles (e.g., wheels, underside) should be sprayed with an EPA-approved disinfectant before leaving the access corridor. The personal clothing and boots of the emergency personnel should be removed for cleaning and disinfection if they had to enter the quarantine area. Disposable clothing can be worn by the emergency personnel and the victim to minimize the potential spread of contamination. The disposable clothing worn by the responders and the victim should be disposed of and secured in plastic bags, and any clothing or equipment thought to be contaminated should be disinfected. In these instances, appropriate hospital authorities should be notified of the risk and necessity for disinfection of the patient and vehicle as soon as circumstances permit.

7.6.4 Equipment

Equipment used on site can serve to transfer microorganisms to other locations and to susceptible animals. This may include any number of items used for the care, treatment, or euthanasia of animals as well as any restraint equipment (e.g., halters, ropes), or materials in contact with infected animals. Many of these items will be difficult to clean. If items cannot be adequately cleaned and disinfected, they should be appraised and disposed of by appropriate means.

Equipment used to euthanize livestock (e.g., captive bolt guns and firearms) should be considered grossly contaminated. After use, these devices should be scrubbed with disinfectant at the location where they were used and again at the disinfection station. C&D equipment (e.g., rakes, shovels, brushes, sprayers) must be cleaned and disinfected after use and stored in a secure location. Items or equipment removed from the area, including those used for cleaning (e.g., brooms, shovels, buckets, hoses), must be disposed of or disinfected before reuse . Special care should be used when cleaning and disinfecting rubber equipment because many disinfectants are corrosive to rubber. Strongly consider requesting an appraisal of these items and destroying them.

7.6.5 Electronics

The most practical method of decontaminating electrical equipment (e.g., generators, motors) involves placing the equipment inside an airtight enclosure (e.g., plastic sheeting) for fumigation. When possible, equipment should be dismantled so all parts can be fumigated. Consultation with an electrician may be necessary. Some electrical items may be inherently airtight, in which case they can be safely decontaminated and disinfected by wiping down with disinfectant. Exposure to ultraviolet light may be another option for disinfecting complex equipment.

Most portable electronic equipment (e.g., hand-held radios, cameras, tape recorders) may be useable while protected inside plastic bags. Upon removal from the infected premises, wipe the protective plastic bag with disinfectant, followed by the body of the item, and then discard the plastic bag. If cameras are needed to record response actions, inexpensive waterproof cameras which would allow for disinfection should be considered.

Additional details on small-scale disinfection stations can be found in the *FAD PReP SOP: Cleaning and Disinfection*.

7.7 Large-Scale Disinfection Station [Vehicles, Heavy Machinery]

Any vehicle used on infected premises or to haul infected animals can potentially transport pathogens from one site to another. These may include cars, livestock carriers, feed trucks, milk trucks, or carcass transporters. These vehicles must be cleaned and disinfected before leaving the area. Heavy machinery used on a contaminated site (e.g., excavators, backhoes, bulldozers) will also be grossly contaminated and require C&D procedures prior to leaving the premises. No vehicle used on infected premises should leave the area without thorough external and internal disinfection. This can be difficult due to the construction and presence of uneven surfaces on vehicles. Inclement weather conditions (e.g., cold, rain) may also make these procedures difficult.

Large-scale disinfection stations should be established to wash and disinfect any number of vehicles or heavy equipment used during the response. Establishing a holding area, where disinfected vehicles can remain during the necessary disinfectant contact time, can help to speed the flow through the station (i.e., some vehicles can be washed and disinfected, while others are in the holding area during the necessary contact time.)

Vehicle C&D should follow the basic C&D protocol described previously (i.e., dry clean, wash, rinse, apply disinfectant, contact time, rinse) to ensure efficacy of the process. All exterior and interior surfaces must be addressed. Disinfectant should be reapplied as necessary to keep the surfaces wet for the required contact time. In these areas, spent fluids and debris should be contained and removed from the area, which can be difficult. The use of berming materials (e.g., sandbags, straw bales) and the subsequent drainage using a sump pump into a holding tank can be effective; however, berming areas must be constructed to withstand vehicle/heavy equipment weight. This can include placement of plywood sheeting on top of the material or the construction of ramps to protect the berms at the entrance and exit. The area should be made at least twice as big as the largest vehicle to allow adequate working room for the C&D personnel.

For highly contagious agents, containment of spray drift and splash may be necessary to prevent aerosol transfer. This can be accomplished by constructing a framing wall covered with plastic sheeting around the containment base. The frame should be at least as high as the tallest vehicle to be disinfected. Personnel cleaning a vehicle should wear protective, waterproof clothing and appropriate personal protective equipment, (e.g., rubber gloves, eye protection) when applying disinfectant solution.

7.7.1 Aircraft or ships

In the event of a highly contagious disease, aircraft or ships used to transport animals may be subject to disinfection measures. Only disinfectants registered by EPA specifically for use on aircraft and determined to be acceptable to the manufacturer of the specific aircraft should be used.

Details on large-scale disinfection stations can be found in the *FAD PReP SOP: Cleaning and Disinfection*.

7.8 Premises

The cleaning and disinfection of infected premises will be necessary as part of the response and recovery plan and must be done before animals are reintroduced to the facility. Premises C&D will vary depending on the situation (e.g., disease agent) and the type of facility (e.g., broiler house, milking parlor, feedlot), but should follow the basic C&D protocol described previously (i.e., dry clean, wash, rinse, apply disinfectant, contact time, rinse) to ensure efficacy of the process. Specific procedures for C&D of premises can be found in the *FAD PReP SOP: Cleaning and Disinfection*.

7.8.1 Interior

Before initiating the C&D process, all fans should be turned off to prevent dissemination of the infectious agent. Drains and runoffs should be identified, blocked, and disinfected. Footbaths should be

set up at all entrances and exits to the building.
In the case of a highly contagious disease, a preliminary pathogen-reduction step may be warranted, particularly if an airborne disease agent is involved. A chosen disinfectant (with efficacy against the pathogen) should be applied using a low-pressure sprayer to damp down dust in the building and prevent further spread of the pathogen. Application should avoid the creation of pools of solution which could enter into drains. This procedure should be implemented as soon as possible after the disease is confirmed.

The electricity supply to the building should be disconnected to allow removal of sensitive equipment and to prevent electrical accidents during cleaning. An alternative supply should be acquired to supply any electrical cleaning equipment. Good lighting is essential to ensure that surfaces are visibly clean after the washing step.

Premises C&D should follow the basic C&D protocol previously described. Special care should be taken to ensure components of any watering systems (e.g., water lines, dispensers, nipple drinkers, troughs), feeding equipment (e.g., feed lines, augers, hoppers), and other mechanical structures within the building (e.g., fans, casings, motors, belts, curtains, ventilation pads, louvers) are thoroughly cleaned and disinfected. Reapply disinfectant as needed to keep the surfaces wet for the required contact time.

Equipment such as thermostats, scales, time clocks, electrical panels, switches, and light bulbs may need to be individually wiped, cleaned, sanitized, and protected from the more severe effects of cleaning--such as high-pressure sprayers and disinfectant chemicals--and protected from recontamination during the cleaning process.

Fumigation can only be performed where it is possible to seal or tent the building completely and requires considerable care to be performed safely and correctly.

7.8.2 Exterior

The immediate area around the exterior of the house must also be cleaned and disinfected. The width of the perimeter will vary depending on the pathogen involved, but may be as wide as 10 feet around the exterior. In some situations, a flame gun may be used on outdoor concrete, brick, or metal surfaces after disinfection. Surfaces should be wet before starting so that flamed and unflamed areas can be easily distinguished. A flame gun should only be used in areas where no combustible materials are present. Attention should be given to ventilation and fan inlets. A low-pressure sprayer should be used to disinfect these areas.

7.8.3 Vectors

Animals that are not susceptible to the targeted disease agent may be present on the premises and could serve to potentially transfer the pathogen to additional areas. Rodents, birds, and other wildlife must be detected and dealt with appropriately. See the *FAD PReP/NAHEMS Guidelines: Wildlife Management and Vector Control* for more information. Areas of potential rodent entrances or penetration should be sealed. Roof areas and eaves with holes or nesting areas for wild birds must be addressed. Feral animals must be trapped and removed or destroyed. Pets should be thoroughly bathed to remove possible sources of the FAD agent from the animal's coat and kept under strict control until the farm has been declared free of infection and the quarantine removed.

7.8.4 Liquid Manure Collection Systems

Given some pathogens may be transmitted via fecal material, issues involving liquid manure collection systems (e.g., slurry pits, lagoons) or other manure containment areas must be addressed. If removal of material had occurred just prior to the infectious disease event, assessment should be made of the potential risk of the disposed material. If the tank is full, measures to safely remove the material should be determined. Thermal or chemical inactivation methods may be required to destroy pathogenic microorganisms. The survival of foot-and-mouth disease, classical swine fever, bovine viral diarrhea and swine influenza viruses in farm slurry under anaerobic conditions was found to be generally short when heated to 131°F (55°C) but retained infectivity at cooler temperatures (41°F/5°C). However, some microbial pathogens (e.g., *Bacillus anthracis* spores) require additional measures to ensure inactivation. Chemical disinfection may involve the addition of products that alter the pH of the slurry for determined periods of time. Once achieved, the decontaminated manure must be returned to a stable pH if application to crop ground is anticipated. Vigorous stirring will be required once a chemical is added to ensure adequate distribution of the disinfectant. The agitation of slurry can release toxic gases such as carbon monoxide, carbon dioxide, hydrogen sulfide, ammonia, and methane; therefore, safety precautions (e.g., ventilation, PPE) should be determined and addressed.

7.8.5 Depopulation and Disposal Sites

Due to the greater concentration and potential for exposure to contagious pathogens at depopulation and disposal sites, C&D activities must be implemented more frequently in efforts to control pathogen spread. Care must be taken to disinfect equipment, machinery, and vehicles involved with these sites. Depopulation areas should be disinfected frequently, but C&D of disposal sites should be conducted once all procedures are completed. Once all heavy machinery and equipment have left the area, C&D personnel should heavily spray the area around the site as well as "roads" used for the site. All heavy equipment used for disposal should be thoroughly cleaned and disinfected following depopulation and disposal procedures.

7.9. Material Composition

The material composition of equipment and items on animal production facilities can be quite diverse. A primary factor to be considered when selecting and performing C&D operations is the kind of surface being treated to ensure the needed efficacy and minimal damage to items. The best surfaces for C&D are nonporous, smooth surfaces; however, these are seldom found in animal production situations. This section addresses considerations or contraindications when cleaning and disinfecting various surface types. This will allow for adaptation of methodology regardless of the production situation involved.

7.9.1 Metals

Metal surfaces (e.g., stainless steel, aluminum) are generally easier to disinfect than other materials, especially when the surfaces are smooth. However, some chemical disinfectants are incompatible or corrosive with metal surfaces (see table below). Flame guns may be a useful alternative for some metal surfaces.

Chemical Disinfectant	Effect on metal surfaces
Sodium hydroxide	Corrosive to aluminum and derived alloys and galvanized metal
Sodium carbonate	Corrosive to aluminum and derived alloys
Acids	Highly corrosive to metals
Glutaraldehyde, Virkon® S	Mildly corrosive to metals
Iodophors, hypochlorites, formaldehyde	Corrosive to some metals
Phenolics	Relatively non-corrosive

7.9.2 Rubber and Plastics

Rubber and plastics should be treated as hard, nonporous surfaces, however they may have interactions with some chemical disinfectant products. Phenols may be absorbed by plastics and 1% sodium hydroxide should be avoided. Iodophors may cause staining of these materials and can be corrosive to some plastics or rubber. Heat treatments can melt most plastics. Alcohols can swell or harden rubber or certain plastic tubing after prolonged and repeated use.

7.9.3 Glass

Glass surfaces should be treated as hard, nonporous surfaces.

7.9.4 Concrete

Raw concrete surfaces are porous and therefore difficult to clean. Porous surfaces should not be rinsed, soaked, or sprayed with plain water prior to washing or disinfectant application as this can cause unintended dilution. A disinfectant solution of a product registered for concrete surfaces should be applied to all surfaces once gross organic debris has been removed and the area has been washed, rinsed, and dried. If a registered product is not available, then an exempted pesticide should be used [see Appendix C]. High pressure washing with a disinfectant solution can be helpful for improving adequate contact of these surfaces, but may cause damage to some concrete surfaces. Acid and hypochlorite disinfectants can be corrosive to concrete surfaces. Flame guns may be an alternative disinfection method for concrete surfaces.

7.9.5 Wood

Wood is extremely porous and therefore difficult to disinfect. Any decaying wood surface that cannot be disinfected should be appraised, removed, and disposed of appropriately (e.g., burn or burial). Wood surfaces should not be rinsed, soaked, or sprayed with plain water prior to washing or disinfectant application as this can cause unintended dilution. A disinfectant solution of a product registered for wood surfaces should be applied once gross organic debris has been removed. If a registered product is not available, then an exempted pesticide should be used.

7.9.6 Soil

No environmentally safe procedures exist for “disinfecting” soil surfaces (e.g, dirt, sand, packed clay).

8. PRODUCTION SITUATIONS

Regardless of the operation, the basic C&D protocol should be used for all situations. There are some special considerations for individual production types which will be addressed here.

8.1 Poultry Premises

Poultry production premises, depending on the type of facility, can have a number of areas or equipment requiring C&D procedures. These may include egg processing equipment such as egg belts, flats, buggies, and packing machines; nesting boxes; and egg storage rooms. Production facilities may also consist of open floor areas which require removal of litter and manure prior to disinfection efforts. Curtains set up within the facility will need to be completely extended to ensure thorough cleaning and disinfection.

8.2 Dairy Facilities

Unique challenges for C&D of dairy operations include milking equipment such as milking units, strainers, coolers, and the bulk tank. Milk film or deposits on equipment can impact disinfection efficacy.

Since the daily operation of dairies involves strict sanitation and disinfection protocols for milking equipment, input and assistance from the dairy manager or personnel may be useful to determine effective disinfection methods that will not cause damage to milking machines and tanks. Labels of products used on milking equipment must specifically list this equipment since they are considered food-contact surfaces and a tolerance or exemption from tolerance is required for such products.

8.3 Swine Facilities

Special situations in swine facilities include farrowing pens, slats, slurry pits and alleys. Farrowing areas can present particular problems for C&D processes due to any number of complex structures (e.g., bars, crates, gates) that can be difficult to clean, as well as electrical equipment that may be sensitive and easily damaged. A further consideration is that after C&D measures, the building will need to house parturient and neo-natal animals; therefore, it is necessary to clean and disinfect without leaving residual chemicals. Phenolic disinfectants should be avoided as they can be toxic to swine.

8.4 Equine Facilities

Equine facility environments are highly variable since they often contain pastures and paddocks as well as extensive porous materials like wood and cement block and variable stall flooring like dirt, clay, sand, rubber, and concrete. The useful "all-in all-out" system used in food production is not applicable in most equine facilities. Cleaning and removing organic materials like dirt, feces, vegetation, and dust are critically important when disinfecting any animal housing system. A disinfectant solution of a product registered for wood and concrete surfaces should be applied once gross organic debris has been removed. If a registered product is not available, then an exempted pesticide (i.e., disinfectant) should be used [see Appendix C]. Non-flammable surfaces may be treated with a flame gun. Special attention should be paid to metal bars on stalls.

8.5 Aquaculture Facilities

There is a great deal of variability in the types of aquaculture facilities (e.g., earthen ponds, tanks, raceways, open ocean culture). Basic C&D procedures are applicable for most aquatic situations. Special considerations for aquaculture facilities include the potential environmental impact of chemical products running off into water environments and disinfection of transport boats or other water equipment (e.g., nets, buckets, scuba equipment). It is important that all C&D activities are in compliance with pertinent environmental policies. Chlorine and iodine are highly toxic for fish and should be neutralized with sodium thiosulfate.

8.6 Prions

Decontamination of prion-contaminated tissues, surfaces, and environments is difficult. These agents are highly resistant to almost all disinfectants (including formalin), heat, ultraviolet radiation, and ionizing radiation, particularly when they are protected in organic material or when the prion titer is high. Prions can bind tightly to some surfaces, including stainless steel and plastic, without losing infectivity. Prions bound to metal seem to be highly resistant to decontamination.

Few effective decontamination techniques have been published, and no disinfectants or sterilants are registered by EPA for reducing the infectivity of prions. However, EPA has issued quarantine exemptions to several states for use of Environ™ LpH™ (a mixture of three phenolic active ingredients) for treatment of surfaces in commercial, government, and veterinary laboratories to reduce the infectivity of prions. A 1-2 N sodium hydroxide solution or a high concentration of sodium hypochlorite containing 2% available chlorine followed by autoclaving has been recommended by the World Health Organization for Animal Health for equipment and surfaces. Surfaces should be treated for more than 1 hour at 20°C (68°F). Overnight disinfection is recommended for equipment.

Physical inactivation of prions can be carried out by autoclaving at 134-138°C (273-280°F) for 18 minutes at 30 lb/in^2. Autoclaving items in water is more effective than autoclaving without immersion. Dry heat is less effective. A combination of chemical and physical decontamination can be more effective than either procedure alone. Chemical disinfection should be carried out first, and then the items should be rinsed and autoclaved. Even the harshest combination of chemical and physical disinfection is not guaranteed to destroy all prions. Because no products have been registered or exempted by EPA for reducing the infectivity of prions in agricultural facilities, an exemption would need to be obtained from EPA for such uses should the need arise.

9. EVALUATION

Inspection of a site following C&D procedures should ensure all tasks detailed on the premise assessment have been performed. Factors to be addressed should include the following:

- All grossly contaminated areas have been identified and properly cleaned and disinfected.
- All personnel are aware of and are implementing C&D measures for themselves and their equipment (e.g., PPE, tools, instruments).
- Appropriate disinfectants were selected.
- Gross debris (e.g., manure, unused feed, or bedding) has been removed and properly disposed of.
- Any contaminated wood or items difficult to disinfect have been appraised, removed, and disposed of in a manner that minimizes spread of pathogens (e.g., burned, composted, buried).
- All fixtures and fittings have been dismantled, cleaned, and disinfected.
- All infected or suspected areas have been properly washed, rinsed, and disinfected. Visual inspection should be conducted to ensure surfaces are clean and no organic material has been left behind.
- An EPA-registered or exempted disinfectant that is efficacious against the target microorganism was used at the appropriate concentration.
- The necessary contact time for the disinfectant was allowed.
- Effluent from the C&D procedures has been handled in a manner to minimize or avoid environmental impact.

Final inspection of the premises should be conducted by experienced personnel. If there is any doubt or sign of inadequate procedures, the disinfection measures must be repeated. Once final inspection of the premises has occurred, any and all personnel present should proceed through the C&D site before leaving the premises.

10. SAFETY ISSUES AND PRECAUTIONS

10.1 Chemical Hazards

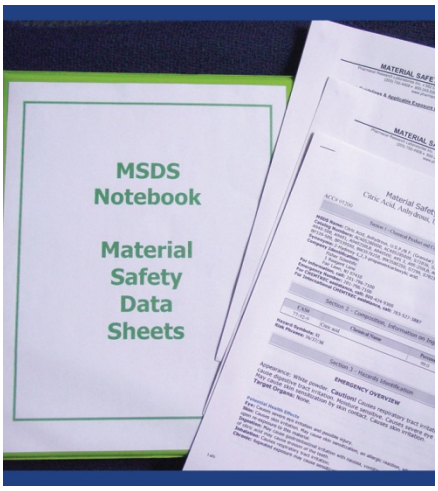
Most chemical disinfectant products have health hazards or risks, such as skin or respiratory irritation or damage as well as eye hazards from splashes. All disinfectants must be used with care to avoid injury or health issues. Personnel preparing and applying chemicals should follow all label safety precautions and wear appropriate PPE (e.g., gloves, goggles), as required. Disinfectants should be stored according to label directions. Disinfectants should not be applied directly to animals unless approved by FDA and labeled for such use. Disinfection of feeders, waterers, or other animal contact areas should be followed by thorough rinsing before reintroduction of animals to avoid accidental ingestion or chemical burns.

10.2 Physical Hazards

During C&D operations, any number of physical hazards may occur. These may include injury from slips, trips, or falls due to slippery conditions. If steam or flame methods are used for disinfection purposes, safety precautions should be taken to reduce the risk of burns to personnel. High pressure sprayers should be used with special care as the potential for skin damage with contact is possible. The generation of dust during C&D efforts can lead to respiratory irritation. For more information, see the *FAD PReP/NAHEMS Guidelines: Health and Safety* .

10.3 Environmental Hazards

Environmental factors, such as runoff into creeks or ponds, must also be considered during animal health emergencies. Runoff of infectious material or chemical solutions must be avoided to prohibit further spread. Many chemical disinfectants are toxic to aquatic organisms; runoff should be controlled to prevent entry into lakes, streams, or ponds.



10.4 Hazard Communication

Before any C&D work is initiated, all members of the team should have a complete orientation covering the nature of the disease and the various hazards that may be encountered while serving during an incident. A complete understanding of the specific safety precautions should be obtained before entering the premises. This is particularly important if a zoonotic disease is involved.

10.5 Personal Protective Equipment

Personnel engaged in cleaning and disinfection operations should wear at a minimum coveralls, boots and gloves. Face protection (e.g., goggles, mask, face shield) should be worn based on the product or application method (e.g., misting) used and when mixing disinfectant solutions. Masks should also be worn in situations involving significant amounts of dust generation or zoonotic disease potential. Additional personal protective equipment, such as chemical-resistant suits (including both pants and jackets with hoods) or respirators may be necessary for some situations (e.g., formaldehyde or acidic disinfectants). For more information on PPE, see the *FAD PReP/NAHEMS Guidelines: Personal Protection Equipment.*

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12. INTERNET RESOURCES

Code of Federal Regulations (CFR) – Title 9
http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title09/9cfrv1_02.tpl

Subchapter C: Interstate Transportation of Animals (including poultry) and Animal Products
Part 71.10 – Permitted disinfectants

Subchapter D: Exportation and Importation of Animals (including poultry) and Animal Products
Part 91.18 – Cleaning and disinfection of transport carriers for export
Part 95.24 – Methods for disinfection of hides, skins and other materials

National Institute for Occupational Safety and Health
Suggested Respirator Cleaning and Sanitation Procedures
http://www.cdc.gov/niosh/npptl/cleaning.html

U.S. Department of Agriculture, Animal and Plant Health Inspection Service
An extensive list of EPA-approved pesticides to use against the causative agents of selected foreign animal diseases in farm settings can be found at
http://www.aphis.usda.gov/animal_health/emergency_management/downloads/fad_epa_disinfectants.pdf.

U.S. Environmental Protection Agency
2009 Code of Federal Regulations-Exemption of Federal and State Agencies for Use of Pesticides Under Emergency Conditions (40 CFR part 166)
http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title40/40cfr166_main_02.tpl

EPA-Antimicrobial Pesticide Definitions. October 8, 2008, Federal Register. vol. 73, No. 196, p. 59431.
http://www.access.gpo.gov/su_docs/fedreg/a081008c.html

Pesticide Emergency Exemptions
www.epa.gov/opprd001/section18.

Registered Antimicrobial Products with Label Claims for Avian (Bird) Flu Disinfectants
http://www.epa.gov/opp00001/factsheets/avian_flu_products.htm

Regulating Pesticides: Laws and Regulations
http://www.epa.gov/opp00001/regulating/laws.htm

Selected EPA-Registered Disinfectants
http://www.epa.gov/oppad001/chemregindex.htm

U.S. EPA Pesticide Product Label System (PPLS)
http://oaspub.epa.gov/pestlabl/ppls.home

13. ACKNOWLEDGMENTS

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14. PHOTO AND ILLUSTRATION CREDITS

Page 1 This graphic shows the level of destruction of microorganisms by disinfection processes. Graphic illustration by: Clint May and Andrew Kingsbury, Iowa State University

Page 2 Graphic showing the Incident Command System (ICS) for the Cleaning and Disinfection Group. Graphic illustration by: Andrew Kingsbury, Iowa State University

Page 5 (**Top**) This graphic shows the steps of the basic C&D protocol. Graphic illustration by: Andrew Kingsbury, Iowa State University
(Bottom) This photo shows a skid loader removing organic material from a barn. Photo source: Danelle Bickett-Weddle, Iowa State University

Page 6 **(Top)** This photo shows a livestock trailer being washed with a pressure sprayer. Photo source: Danelle Bickett-Weddle, Iowa State University
(Bottom) This graphic shows a basic amphiphilic chemical structure of surfactants due to the interaction of hydrophilic and hydrophobic molecules to form a micelle. Graphic illustration by: Andrew Kingsbury, Iowa State University

Page 8 This illustration reflects the logarithmic rate of thermal destruction of microorganisms. Graphic illustration by: Andrew Kingsbury, Iowa State University

Page 9 This graphic reflects how DNA bonds are destroyed by ultraviolet radiation. Graphic illustration by: Andrew Kingsbury, Iowa State University

Page 10 This graphic shows a sample EPA Registration Number found on a mock disinfectant label. Graphic illustration by: Clint May and Andrew Kingsbury, Iowa State University

Page 17 This graphic shows the susceptibility of various microorganism classes to chemical disinfectants. Graphic illustration by: Clint May and Andrew Kingsbury, Iowa State University

Page 18 This graphic shows a sample use concentration and efficacy section of a mock disinfectant product label. Graphic illustration by: Clint May and Andrew Kingsbury, Iowa State University

Page 19 This graphic lists the various environmental considerations when selecting a disinfection method and product. Graphic illustration by: Andrew Kingsbury, Iowa State University

Page 20 This graphic lists main points in assessment and planning for cleaning and disinfection procedures. Graphic illustration by: Andrew Kingsbury, Iowa State University

Page 23 **(Top)** Figure 1 shows a sample layout of the various work zones for a premises. Graphic illustration by: Dani Ausen and Andrew Kingsbury, Iowa State University
(Bottom) Figure 2 shows the decontamination corridor. Graphic illustration by: Dani Ausen and Andrew Kingsbury, Iowa State University

Page 24 This photo shows a test kit that checks for iodine concentration. Photo source: Teresa Robinson, USDA

Page 25 This photo shows PPE disinfection. Photo source: Gordon Harman, FEMA Center for Domestic Preparedness

Page 26 This photo shows various fomites (e.g., halters, lead ropes) which can serve to spread pathogens on a farm. Photo source: Danelle Bickett-Weddle, Iowa State University

Page 27 **(Top)** This photo shows a responder in PPE disinfecting farm equipment. Photo source: Canadian Food Inspection Agency
(Bottom) This photo shows various surfaces and compositions of items (e.g., wood, concrete, metal) to be disinfected in animal settings. Photo source: Alex Ramirez, Iowa State University

Page 28 These photos show structures on the exterior of a building that should be included in cleaning and disinfection operations. Top: Ventilation fans; Bottom: exterior perimeter. Photo source: Veterinary Diagnostic and Production Animal Medicine, Iowa State University (top) and Danelle Bickett-Weddle, Iowa State University (bottom)

Page 30 This photo shows a cleaned barn stall showing various surfaces. Photo source: Carla Huston, Mississippi State University

Page 33 This photo shows a sample material safety and data sheet (MSDS) notebook. Photo source: Dani Ausen, Iowa State University

Glossary

Antiseptic
Products approved and used to reduce the risk of infection by killing or inhibiting the growth of microorganisms on the skin. Because these products are used in or on humans or animals, they are considered drugs and are approved and regulated by the U.S. Food and Drug Administration (FDA).

Cleaning and Disinfection (C&D)
Practices involving a combination of physical and chemical processes that kill or remove pathogenic microorganisms—a combination that is vital for the eradication of disease.

Cold Zone -- Support Zone (SZ)
This is the "cleanest" work zone with the lowest relative risk of exposure to pathogens and other hazards such as decontamination chemicals. In this zone personnel are not required to wear PPE; however, facilities for donning PPE before entering other zones are provided. Administrative, clerical, and other support functions are based here. Medical support is provided to personnel in this zone. Facilities for personal needs such as eating, drinking, and bathroom use are provided. Air and surface monitoring is conducted as needed to ensure that the area is free from contamination. Contaminated articles and equipment are prohibited in this area. Decontamination activities are also prohibited.

Decontamination Corridor
The area between the Hot Zone - Exclusion Zone (EZ) Control Line and the Warm Zone - Contamination Reduction Zone (CRZ) Control Line. Decontamination of personnel and equipment occurs along the corridor with stations for depositing tools, equipment, protective clothing, and other items. The level of contamination should decrease along the path from the Hot Zone - Exclusion Zone (EZ) to the Cold Zone - Support Zone (SZ). Teams enter and exit the Hot Zone - Exclusion Zone **(**EZ) through the access control points at each end of the corridor.

Detergent
Chemical products used to disperse and remove soil and organic materials from surfaces by reducing surface tension and increasing the penetrating ability of water. This can improve a disinfectant's ability to reach and destroy microbes within or beneath the dirt. Some disinfectants (i.e., quaternary ammonium compounds) have detergent properties.

Disinfectant
A substance used on inanimate surfaces that destroys or eliminates a specific species of infectious or other public health microorganism, but not necessarily bacterial spores, in the inanimate environment. Disinfectants are regulated by the U.S. Environmental Protection Agency (EPA). Disinfection can also be achieved by physical means (e.g., heat, light).

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
Federal Act that provides the US Environmental Protection Agency the authority to regulate the sale, distribution, and use of pesticides in the US; FIFRA also authorizes EPA to suspend or cancel the registration of a pesticide if it determines that the pesticide will likely cause unreasonable adverse effects to humans or the environment.

Fomites
Inanimate objects or material on which disease-producing agents may be conveyed (e.g., equipment, vehicles, feces, bedding, halters, ropes, buckets).

Hot Zone -- Exclusion Zone (EZ)
This high-risk area is where infected animals were housed and is potentially contaminated and considered unsafe. Examples include an area of a farm, local market, or roadside stand. PPE must be worn. Appraisal, depopulation, disposal, and facility cleaning and decontamination of the site and equipment

occur in this area. Personnel and equipment enter and exit the Hot Zone through designated access points in the Warm Zone - Contamination Reduction Zone (CRZ).

Pasteurization
The application of heat to food or liquid items (e.g., milk, cheese) to an elevated temperature for a period of time (e.g., 145°F [63°C] for 30 minutes) to destroy certain microorganisms without radically altering taste or quality. This process is considered a mild disinfection process as it does not kill all microorganisms.

Poultry
Note there are varied definitions of poultry throughout the Code of Federal Regulations. One definition of poultry provided in 9 CFR 53 is as follows: chickens, ducks, geese, swans, turkeys, pigeons, doves, pheasants, grouse, partridges, quail, guinea fowl, and pea fowl

Premises
Includes a tract of land and all of its buildings, as well as a separate farm or facility that is maintained by a single set of services and personnel.

Relative Humidity
A ratio, expressed in percent, of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated. Since the latter amount is dependent on temperature, relative humidity is a function of both moisture content and temperature. Relative humidity is derived from the associated temperature and dew point for the indicated hour (NOAA).

Sanitizer
A substance that reduces the bacterial population in the inanimate environment by significant numbers, but does not destroy or eliminate all bacteria or other microorganisms.

Slurry Tank
A tank that contains a suspension of solids in liquid, usually animal manure.

State
Any of the States, the District of Columbia, the Commonwealth of Puerto Rico, Guam, the Commonwealth of the Northern Mariana Islands, the Virgin Islands of the United States, or any territory or possession of the United States (Animal Health Protection Act 2002).

Sterilant
A substance that destroys or eliminates all forms of microbial life in the inanimate environment, including all forms of vegetative bacteria, bacterial spores, fungi, fungal spores, and viruses. Sterilization can also be achieved by physical means (e.g., heat, light, irradiation).

Ultraviolet
The part of the electromagnetic spectrum that cannot be seen by the human eye, extending from approximately 240 nm to 330 nm.

Vegetative
Stage when nutrition is being taken up and growth occurs.

Viral Envelope
The lipoprotein outer covering of virions of some viruses, derived from cellular membranes but containing virus-specific proteins, usually glycoproteins.

Warm Zone -- Contamination Reduction Zone (CRZ)
This is a high-risk area due to the potential of exposure to pathogens and chemical disinfectants. All personnel are required to wear full PPE. Entry from the Warm Zone - Contamination Reduction Zone (CRZ) to either the Cold Zone - Support Zone (SZ) or Hot Zone - Exclusion Zone (EZ) occurs through designated access points. For workers exiting the Hot Zone - Exclusion Zone (EZ), final decontamination and disinfection of PPE and equipment, as well as final doffing of PPE occur in the Decontamination Corridor of the Warm Zone - Contamination Reduction Zone (CRZ). Site-specific protocols for PPE, decontamination, and disinfection must be strictly followed.

World Organization for Animal Health (OIE)

The intergovernmental organization created by the International Agreement of 25 January 1924, signed by 28 countries; the OIE now includes over 170 Member Countries. OIE standards are recognized by the World Trade Organization as reference international sanitary rules. The purpose of the OIE is to guarantee the transparency of animal disease status world-wide.

Zoonotic Disease

Disease that is transmissible from animals to humans under natural conditions.

Acronyms

APHIS
Animal and Plant Health Inspection Service

C&D
Cleaning and Disinfection

CFR
Code of Federal Regulations

CRZ
Contamination Reduction Zone

EMRS
Emergency Management Response System

EPA
U.S. Environmental Protection Agency

ERAS
Environmental and Risk Analysis Services

EZ
Exclusion Zone

FAD
Foreign Animal Disease

FAD PReP
Foreign Animal Disease Preparedness and Response Plan

FDA
U.S. Food and Drug Administration

FIFRA
Federal Insecticide, Fungicide, and Rodenticide Act

FMD
Foot-and-Mouth Disease

HEPA
High Efficiency Particulate Air

ICS
Incident Command System

MSDS
Material Safety and Data Sheet

NAHEMS
National Animal Health Emergency Management System

NAHERC
National Animal Health Emergency Response Corps

NPIRS
National Pesticide Information Retrieval System

OIE
World Organization for Animal Health

OSHA
Occupational Safety and Health Administration

PPD
Policy and Program Development

PPE
Personal Protective Equipment

PPLS
Pesticide Product Label System

QAC
Quaternary Ammonium Compounds

SOP
Standard Operating Procedures

SZ
Support Zone

USAMRIID
United States Army Medical Research Institute for Infectious Disease

USDA
United States Department of Agriculture

VS
Veterinary Services; a division of APHIS

APPENDIX A: THE IMPERATIVE FOR FOREIGN ANIMAL DISEASE PREPAREDNESS AND RESPONSE

Why Foreign Animal Diseases Matter

Preparing for and responding to foreign animal diseases (FADs)—such as highly pathogenic avian influenza (HPAI) and foot-and-mouth disease (FMD)—are critical actions to safeguard the nation's animal health, food system, public health, environment, and economy. FAD PReP, or the *Foreign Animal Disease Preparedness and Response Plan,* prepares for such events.

Studies have estimated a likely national welfare loss between $2.3–69 billion[1] for an FMD outbreak in California, depending on delay in diagnosing the disease.[2] The economic impact would result from lost international trade and disrupted interstate trade, as well as from costs directly associated with the eradication effort, such as depopulation, indemnity, carcass disposal, and cleaning and disinfection. In addition, there would be direct and indirect costs related to foregone production, unemployment, and losses in related businesses. The social and psychological impact on owners and growers would be severe. Zoonotic diseases, such as HPAI and Nipah/Hendra may also pose a threat to public health.

Challenges of Responding to an FAD Event

Responding to an FAD event—large or small—may be complex and difficult, challenging all stakeholders involved. Response activities require significant prior preparation. There will be imminent and problematic disruptions to interstate commerce and international trade.

A response effort must have the capability to be rapidly scaled according to the incident. This may involve many resources, personnel, and countermeasures. Not all emergency responders may have the specific food and agriculture skills required in areas such as biosecurity, quarantine and movement control, epidemiological investigation, diagnostic testing, depopulation, disposal, and possibly emergency vaccination.

Establishing commonly accepted and understood response goals and guidelines, as accomplished by the FAD PReP materials, will help to broaden awareness of accepted objectives as well as potential problems.

[1] Carpenter TE, O'Brien JM, Hagerman AD, & McCarl BA. 2011. "Epidemic and economic impacts of delayed detection of foot-and-mouth disease: a case study of a simulated outbreak in California." *J Vet Diagn Invest.* 23:26-33.
[2] Estimates based on models may vary: Ekboir (1999) estimated a loss of between $8.5 and $13.5 billion for an FMD outbreak in California. Ekboir JM. 1999. "Potential Impact of Foot-and-Mouth Disease in California: the Role and Contribution of Animal Health Surveillance and Monitoring Services." *Agricultural Issues Center.* University of California, Davis.

Lessons Learned from Past FAD Outbreaks

The foundation of FAD PReP is lessons learned in managing past FAD incidents. FAD PReP is based on the following:

- Providing processes for emergency planning that respect local knowledge.
- Integrating State-Federal-Tribal-industry planning processes.
- Ensuring that there are clearly defined, obtainable, and unified goals for response.
- Having a Unified Command with a proper delegation of authority that is able to act with speed and certainty.
- Employing science- and risk-based management approaches to FAD response.
- Ensuring that all guidelines, strategies, and procedures are communicated effectively to responders and stakeholders.
- Identifying resources and trained personnel required for an effective incident response.
- Trying to resolve competing interests prior to an outbreak and addressing them quickly during an outbreak.
- Achieving rapid FAD detection and tracing.

FAD PReP Mission and Goals

The mission of FAD PReP is to raise awareness, expectations, and develop capabilities surrounding FAD preparedness and response. The goal of FAD PReP is to integrate, synchronize, and deconflict preparedness and response capabilities as much as possible before an outbreak by providing goals, guidelines, strategies, and procedures that are clear, comprehensive, easily readable, easily updated, and that comply with the National Incident Management System.

In the event of an FAD outbreak, the three key response goals are to: (*1) detect, control, and contain the FAD in animals as quickly as possible; (2) eradicate the FAD using strategies that seek to stabilize animal agriculture, the food supply, the economy, and to protect public health and the environment; and (3) provide science- and risk-based approaches and systems to facilitate continuity of business for non-infected animals and non-contaminated animal products.* Achieving these three goals will allow individual livestock facilities, States, Tribes, regions, and industries to resume normal production as quickly as possible. They will also allow the United States to regain FAD-free status without the response effort causing more disruption and damage than the disease outbreak itself.

FAD PReP Documents and Materials

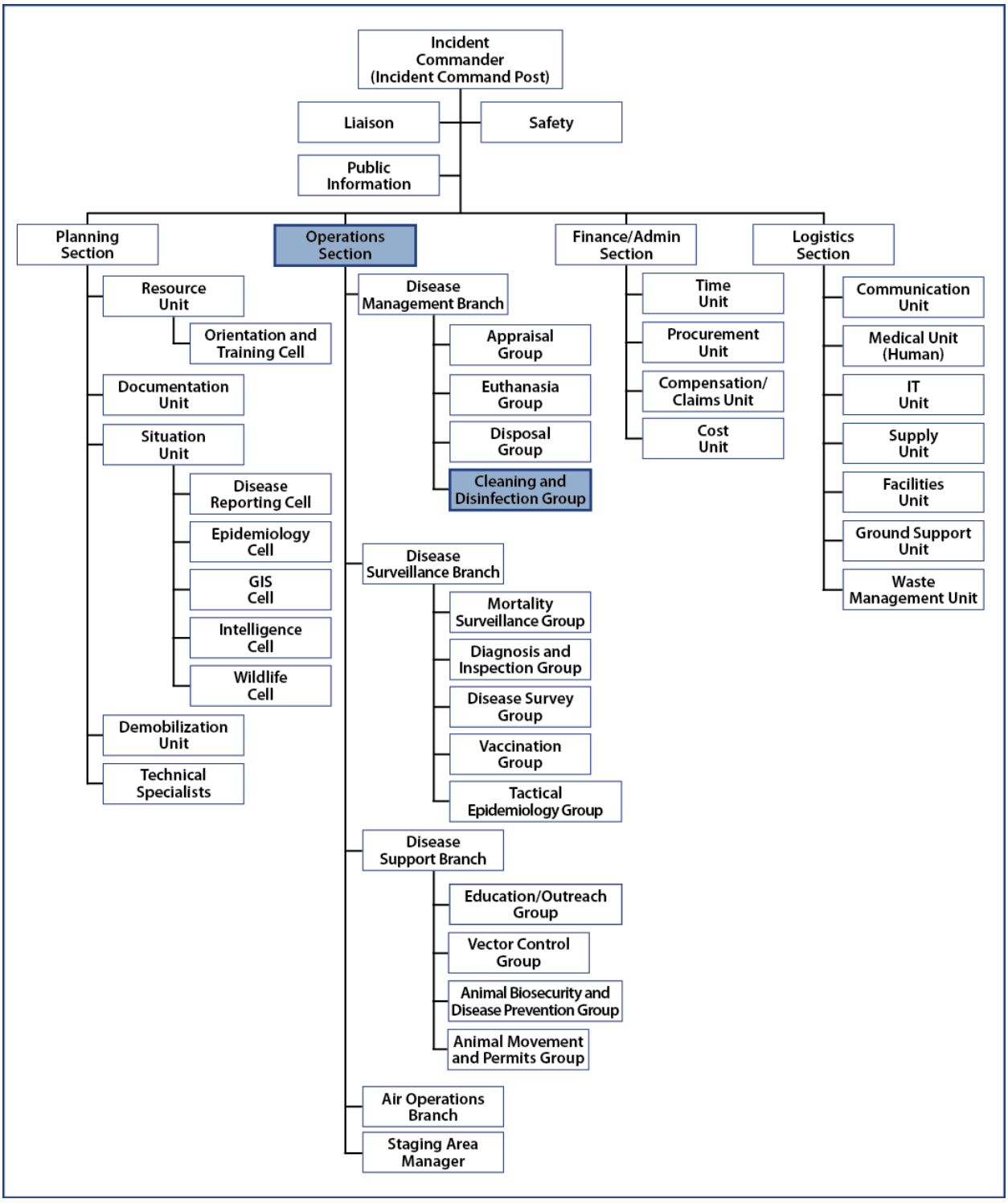
FAD PReP is not just one, standalone FAD plan. Instead, it is a comprehensive U.S. preparedness and response strategy for FAD threats, both zoonotic and non-zoonotic. The following section provides examples of the different types of FAD PReP documents available.

- Strategic Plans—Concept of Operations
  - *APHIS Foreign Animal Disease Framework: Roles and Coordination* (FAD PReP Manual 1-0): This document provides an overall concept of operations for FAD preparedness and response for APHIS, explaining the framework of existing approaches, systems, and relationships.
  - *APHIS Foreign Animal Disease Framework: Response Strategies* (FAD PReP Manual 2-0): This document provides significant detail on response strategies that will be conducted in an FAD outbreak.
  - *Incident Coordination Group Plan* (FAD PReP Manual 3-0): This document explains how APHIS headquarters will organize in the event of an animal health emergency.
  - *FAD Investigation Manual* (FAD PReP Manual 4-0): This field-ready manual provides detailed information on completing an FAD investigation from start to finish.

  - *A Partial List of FAD Stakeholders* (FAD PReP Manual 5-0): This guide identifies key stakeholders with whom the National Preparedness and Incident Coordination (NPIC) Center collaborates.
- NAHEMS Guidelines
  - These documents describe many of the critical preparedness and response activities, and can be considered as a competent veterinary authority for responders, planners, and policy-makers.
- Industry Manuals
  - These manuals describe the complexity of industry to emergency planners and responders and provide industry a window into emergency response.
- Disease Response Plans
  - Response plans are intended to provide disease-specific information about response strategies. They offer guidance to all stakeholders on capabilities and critical activities that would be required to respond to an FAD outbreak.
- Standard Operating Procedures (SOPs) for Critical Activities
  - For planners and responders, these SOPs provide details for conducting critical activities such as disposal, depopulation, cleaning and disinfection, and biosecurity that are essential to effective preparedness and response to an FAD outbreak. These SOPs provide operational details that are not discussed in depth in strategy documents or disease-specific response plans.
- Continuity of Business Plans (commodity specific plans developed by public-private-academic partnerships)
  - Known as the Secure Food Supply Plans, these materials use science- and risk-based information to facilitate market continuity for specific products in an outbreak.
  - More information on these plans can be found at the following: www.secureeggsupply.com, www.securepork.org, www.securemilksupply.org, www.securebroilersupply.com.
- APHIS Emergency Management
  - APHIS Directives and Veterinary Services (VS) Guidance Documents provide important emergency management policy. These documents provide guidance on topics ranging from emergency mobilization, to FAD investigations, to protecting personnel from HPAI.

For those with access to the APHIS intranet, these documents are available on the internal APHIS FAD PReP website: http://inside.aphis.usda.gov/vs/em/fadprep.shtml. Most documents are available publicly, at http://www.aphis.usda.gov/fadprep.

APPENDIX B: SAMPLE INCIDENT COMMAND DIAGRAM FOR ANIMAL HEALTH EMERGENCIES



APPENDIX C: DISINFECTANTS APPROVED UNDER FIFRA SECTION 18 FOR USE AGAINST VARIOUS FOREIGN ANIMAL DISEASE AGENTS BY USDA-APHIS ONLY

	Disinfectant(s) approved for APHIS Use Only			
Foreign Animal Disease Agent	Sodium Carbonate (4%)	Sodium Carbonate (4%) and Sodium Silicate (0.1%)	Sodium Hydroxide (2%)	Sodium Hypochlorite (up to 12.5%)
African horse sickness virus	X	X	X	X
African swine fever virus *	X	X	X	X
Bluetongue virus	X	X	X	X
Classical swine fever virus	X	X	X	X
Contagious bovine pleuropneumonia (*Mycoplasma mycoides mycoides*)	X	X	X	X
Foot-and-mouth disease virus*	X	X	X	X
Highly pathogenic avian influenza virus	X	X	X	X
Lumpy skin disease virus	X	X	X	X
Newcastle disease virus	X	X	X	X
Rift Valley fever virus	X	X	X	X
Sheep pox and goat pox virus	X	X	X	X
Swine vesicular disease virus	X	X	X	X
Vesicular stomatitis virus	X	X	X	X

*In October 2012, the EPA approved the use of citric acid to control FMD and African swine fever in the U.S. for FIFRA quarantine exemption situations. See http://www.aphis.usda.gov/animal_health/emergency_management/downloads/citric_acid_sec18_authorization_amendment.pdf for more information.

APPENDIX D: SUSCEPTIBILITY OF MICROORGANISMS TO CHEMICAL DISINFECTANTS

Chemical Disinfectants		Microorganisms					
		Vegetative bacteria	Enveloped viruses	Non-enveloped viruses	Bacterial spores	Acid-fast bacteria	Prions[c]
Acids	hydrochloric, sulfuric, acetic	+	+	-	±	-	-
Alcohols	ethyl alcohol, isopropanol	++	+	-	-	+	-
Aldehydes	formaldehyde, glutaraldehyde	++	++	+	±[c]	+	-
Alkalis	sodium hydroxide, calcium hydroxide, calcium carbonate	+	+	±	±	+	-
Biguanides	chlorhexidine	++	±	-	-	-	-
Chlorine Compounds	sodium hypochlorite	+	+	+	+	+	-
Iodine Compounds		+	+	±	+	+	-
Oxidizing Agents		+	+	±	+[b]	±	-
Phenolic Compounds	o-phenylophenol	++	±[a]	-	-	±	-
Quaternary Ammonium Compounds		++	±	-	-	-	-

++ highly effective
+ effective
± limited or variable
– no activity

(a) varies with composition of disinfectant
(b) hydrogen peroxide combined with peracetic acid, strong oxidizing agents, is sporicidal
(c) formaldehyde is sporicidal, glutaraldehyde is not.

Adapted from NAHEMS Operational Guidelines: Cleaning and Disinfection , November 2005; Disinfection in Veterinary and Farm Animal Practice. 1987. Linton, AH; Hugo, WB; and Russell, AD (Eds); Blackwell Scientific Publications, London (179 pgs.).

APPENDIX E: SELECT FADS, ETIOLOGY, SPECIES AFFECTED AND ZOONOTIC NATURE

Foreign Animal Disease	Agent Type	Species Affected	Zoonotic
Bacteria			
Glanders	*Burkholderia mallei*	equine; feline, canine, caprine, ovine, camelids	yes
Heartwater	*Ehrlichia (*formerly *Cowdria) ruminantium*	ruminants: bovine, ovine, caprine	no
Contagious bovine pleuropneumonia	*Mycoplasma mycoides mycoides*	bovine	no
Contagious caprine pleuropneumonia	*Mycoplasma capricolum subsp. capripneumoniae*	caprine	no
Contagious equine metritis	*Taylorella equigenitalis*	Equine	no
Enveloped Viruses			
African horse sickness	Reoviridae	equine	no
African swine fever	Asfarviridae	swine	no
Akabane	Bunyaviridae	ruminants: bovine, ovine, caprine	no
Avian influenza	Orthomyxoviridae	avian	yes
Classical swine fever	Flaviviridae	swine	no
Hendra	Paramyxoviridae	fruit bats, equine, feline	yes
Japanese encephalitis	Flaviviridae	avian, swine	yes
Lumpy skin disease	Poxviridae	bovine	no
Nairobi sheep disease	Bunyaviridae	caprine, ovine	yes, mild
Newcastle disease (virulent)	Paramyxoviridae	avian	yes, minor
Nipah	Paramyxoviridae	fruit bats, swine, canine, feline, equine, caprine	yes
Peste des petits ruminants	Paramyxoviridae	ovine, caprine	no
Rabbit hemorrhagic disease	Caliciviridae	rabbits	no
Rift Valley fever	Bunyaviridae	ovine, caprine, bovine, canine	yes
Schmallenberg	Bunyaviridae	bovine, ovine, caprine	no
Sheep pox and goat pox	Poxviridae	ovine, caprine	no
Swine vesicular disease	Picornaviridae	swine	no
Venezuelan equine encephalitis	Togaviridae	avian, equine, rodent	yes
Vesicular stomatitis	Rhabdoviridae	cattle, equine, swine, ovine, caprine	yes

SELECT FADS, ETIOLOGY, SPECIES AFFECTED AND ZOONOTIC NATURE, CON'T

Foreign Animal Disease	Agent Type	Species Affected	Zoonotic
Non-Enveloped Viruses			
African horse sickness	Reoviridae	equine	no
Bluetongue	Reoviridae	ruminants: ovine, caprine, bovine, deer, elk	no
Foot-and-mouth disease	Picornaviridae	cloven-hooved: bovine, swine, ovine, caprine, deer	no
Swine vesicular disease	Picornaviridae	swine	yes
Protozoal			
Bovine babesiosis (cattle fever)	*Babesia bovis, B. bigemina*	bovine	no
Dourine	*Trypanosoma equiperdum.*	equine	no
Equine piroplasmosis	*Babesia caball, Theileria equi* (formerly *Babesia equi)*	equine	no
Surra	*Trypanosoma evansi*	most mammals	no
(Tropical) Theileriosis	*Theileria annulata, Theileria annulata*	bovine	no
Prion			
Bovine spongiform encephalopathy	Prion	bovine	yes
Parasitic			
Screwworm myiasis	Larvae of *Cochliomyia hominivorax* (Coquerel) - New World screwworm; *Chrysomya bezziana* (Villeneuve) - Old World screwworm	all mammals	yes

This information was developed by staff veterinarians at the CFSPH and approved by APHIS for use as training materials for the USDA APHIS National Animal Health Emergency Management System.

the Center for Food Security & Public Health
Iowa State University

APPENDIX F: BASIC C&D EQUIPMENT AND SUPPLIES LISTING

Cleaning and Disinfecting Equipment and Supplies for a C&D Team:

INDIVIDUAL EQUIPMENT
(Each member's personal equipment)

1 pair	Coveralls – cloth
2 pair	Coveralls – disposable
1 each	Coat – waterproof
1 each	Pants – waterproof
1 each	Hat – waterproof
1 pair	Gloves - heavy gauntlet rubber
5 pair	Gloves - surgical rubber (for fine work if needed)
3 each	Masks – surgical (if needed)
1 each	Respirator (if needed)

HAND TOOLS

2 each	Claws hammer
2 each	Plier's
2 each	Screwdriver
2 each	Philips screwdriver
2 each	Crescent wrench (12 inch)
2 each	Crowbar
2 each	Hatchet
2 dozen	Wire brushes (with scraper nose)
	Fiber brushes (long handled)
6 each	Pails (12-14 quart)
2 dozen	Sponges
1 each	Tent (or other shelter)
2 each	Axe
2 each	Shovels (flat)
2 each	Fork (manure)
3 each	Brooms (heavy)
4 each	Hoes
2 each	Garden rakes
2 each	Scrapers (long handled) (e.g., ice scrapers or straighten hoes)
2 each	Post-hole digger
3 each	Hose (3/4 inch x 25 foot)
1 each	Shop vacuum
1 each	Electrical cord (12 ga – 100 ft)

POWER TOOLS & EQUIPMENT

1 each	Power spray unit and tank
2 each	Spray nozzle
1 each	Safety can (5 gallon – with gas)
5 each	Hose (3.4 inch x 50 foot)

MISCELLANEOUS

10 pair*	Rubber gloves
4 each*	Safety goggles
2 each	Plastic tub (10 gallon)
2 each	Metal cans (10 gallon)
2 each	Garbage can (galvanized – 30 gallon)
100 each	Plastic bag (8 mil-50 gallon) – for debris
50 each	Plastic Bag (4 mil – 30 gallon) – for clothes and miscellaneous
1 each	First Aid Kit with EYE WASH
1 gallon per person	Bottled water (in pint or quart portions)
1 quart per person	Sports drink

CHEMICALS

1 gallon	Detergent (liquid)
	Virkon® S
	Bleach
100 lbs for 300 gallons working solution	Soda Ash (Sec. 18) (anhydrous sodium carbonate [Na_2CO_3]) 4%w/v=1 lb/3gallons water
50 lbs for 300 gallons working solution	Lye (Sec. 18)_ (sodium hydroxide [NaOH]) 2%w/v=1 lb/6 gallons water)
	Test strips for disinfectant concentration
	Other suitable