

CLEANING AND DISINFECTION

Standard Operating Guide No. 004

MISSOURI DEPARTMENT OF AGRICULTURE
AGRICULTURAL EMERGENCY RESPONSE ACTIONS
LIVESTOCK DISEASE EMERGENCY



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1.0 SCOPE AND APPLICATION

The purpose of this standard operating guide (SOG) is to provide functional guidance about the establishment, operation, and maintenance of cleaning and disinfection (C&D) areas during a foreign animal disease (FAD) outbreak. This SOG also covers biosecurity procedures needed for responders to prevent the additional spread of a FAD outbreak. This guidance is compatible with Missouri Department of Agriculture’s (MDA) Animal Health Emergency Response and Recovery Plan. Local emergency management should use this SOG as a template. It should be modified as appropriate, and it should be made consistent with the Local Emergency Operations Plan (LEOP). Several sections of this SOG contain general descriptions of the scope of operations necessary to implement a particular component of cleaning and disinfection. In most cases, these sections were made general so that local emergency planners could insert or reference more detailed, county-specific operational details. Examples of these sections include Health and Safety and Communication.

This SOG does not address the C&D of premises. The United States Department of Agriculture’s Animal and Plant Health Inspection Service provides guidance about premise cleaning and disinfection in its document, “Cleaning and Disinfection,” part of the National Animal Health Emergency Management System (NAHEMS) Guidelines (NAHEMS 2005). This SOG contains information from and is consistent with NAHEMS guidelines as of October 2008.

2.0 SUMMARY OF PROCEDURES

One of the primary means of spreading FAD is through movement of infected animals, animal products, or fomites (e.g., feces, bedding, vehicles and other contaminated equipment) conveying disease-producing agents to locations where they come into contact with susceptible animals. When responding to a FAD outbreak, local responders play an important role in preventing the additional spread of the disease. The actions taken to disinfect equipment, vehicles and personnel involved in the response will directly impact the ability to quickly contain the disease. Correctly applied, C&D will prevent the movement of microorganisms on fomites and prevent



the contamination of fomites or infection of susceptible animals that come in contact with areas where infected animals were housed.

FAD transmission to susceptible species (including humans in the case of zoonotic diseases) may occur in the following three pathways (NAHEMS 2003):

- Directly, via animal contact with an infected animal or infected animal products, including blood; secretions (e.g., milk and saliva); excretions (e.g., manure and urine); epidermal outgrowths (feathers, hair, wool, horns and hooves); and exhaled moisture.
- Indirectly, via animal contact with contaminated feed and water; fomites (e.g., clothing, tools, equipment, vehicles, bedding, supplies and other inanimate objects); and people or animals (e.g., roaming and scavenging wildlife—including vermin and dogs—on the premises and surrounding areas) who are contaminated with a pathogen, but not infected or susceptible to it.
- Through arthropod vectors (e.g., insects and ticks) that may serve either as mechanical carriers of a disease agent or as an important part of the life cycle of the agent (e.g., mosquitoes that carry the Rift Valley fever agent).

This SOG is designed to outline general cleaning and biosecurity procedures. Most of the information covered pertains to any disinfection and cleaning needed; however, this SOG specifically covers special concerns associated with access corridors, mortality disposal and temporarily housing animals. Please refer to MDA SOGs 001, 002 and 003, respectively, for additional information about these three topics.

Local emergency managers are encouraged to work with local veterinarians when developing county operation plans associated with biosecurity requirements. In addition, the county also can encourage local producers to implement these procedures at their operations.

2.1 Cleaning and Disinfection

Microorganisms, viruses and spores associated with the spread of a FAD can spread to non-infected animals in many ways. Many mechanisms for disease spread cannot be controlled by responders; for example, disease spread through the atmosphere via wind. Responders can



directly control some mechanisms for spread. These mechanisms involve the spread of a disease through human and animal movement, the reuse of contaminated equipment, and vehicle movement. FAD agents can be found in soil, fodder, manure, feed and bedding; on building surfaces, equipment and animals; and in the atmosphere at an infected location. Responders can be exposed to, and become carriers of, the FAD agent by simply being in the atmosphere of an infected location or stepping in, handling, or otherwise contacting materials or objects that are contaminated. Besides being found in visible contamination, such as dirty boots or coveralls, the FAD agents can adhere to clothing, respiratory tract, hair and skin. Cleaning and disinfection are the tools that responders have to limit the potential for FAD spread outside a quarantine zone.

All vehicles, equipment and personnel that exit a quarantine area, infected premises or temporary animal housing facility must be cleaned and disinfected or their disposable coverings removed and then disposed of. This will be achieved through the physical removal of potentially contaminated materials and through the application of appropriate disinfectant(s). A common problem for all contact disinfectants is maintaining the agent's liquid state on the applied surface. These solutions are generally composed of water, which tends to evaporate prior to the completion of the required contact time. Monitoring of the applied disinfectant and repeated application as it dries can solve this challenge. A general description of common contagious animal diseases and possible disinfectants is presented in Table 1. In addition, the National Biosecurity Center has a disinfectant and animal disease database that can be accessed at <http://www.biosecuritycenter.org/disinfect.php>. This database allows an animal disease to be entered and all appropriate disinfectants are listed for that disease.

The appropriate place to operate and maintain a disinfection station is at an access corridor and at the entrance/exit of disposal areas, infected premises and temporary animal housing locations. The equipment, design and method for implementing personnel, equipment and vehicle cleaning and disinfection stations are described below.



Table 1
Common Contagious Animal Diseases

Disease	Species Affected	Transmission	Best Disinfectant
African Swine Fever	Swine	Ingestion, contact, ticks	Category A
Influenza (avian, equine, swine)	Birds, horses, swine	Aerosols, ingestion	Category A
Newcastle Disease	Birds	Aerosols, ingestion	Category A
Renderpest	Ruminants, cattle	Aerosols, ingestion	Category A
Peste des Petis	Small ruminants	Aerosols, ingestion	Category A
Foot-and-Mouth Disease	Cloven hoofed animals	Aerosols, ingestion	Category B ¹
Swine Vesicular Disease	Swine	Aerosols, ingestion	Category A
Classical Swine Fever	Swine	Contact, ingestion	Category A
Porcine Respiratory and Reproductive Syndrome (PRRS)	Swine	Contact, aerosols	Category A

Notes: Modified from Agriculture and Resource Management Council of Australia and New Zealand, 2000

A Best disinfectants are detergents, hypochlorites, alkalis, Virkon®, and gluteraldehyde.

B Best disinfectants are hypochlorites, alkalis, Virkon®, and gluteraldehyde. Bactericides, like quarternary ammonia compounds and phenolics, are not effective against these viruses.

¹ Acids are effective for Foot-and-Mouth virus.

2.2 Equipment

The equipment needed to supply a disinfection station is presented below. Three distinct classes of cleaning and disinfection equipment are discussed: personal protective equipment (PPE), equipment for cleaning and disinfection, and disinfectants.

- PPE: water, hard hat, safety glasses or face shield, rubber boots, rain suit (jacket and coveralls), cotton overalls or disposable coveralls, disposable synthetic impermeable under gloves (nitrile, latex, etc.), disposable synthetic impermeable over gloves (nitrile, rubber, etc.), heavy-duty over gloves (cotton or leather), boot tray or bucket, 1- to 2-gallon hand-operated pressure sprayer, short-handled scrubbing brushes, and heavy duty plastic garbage bags.
- Cleaning equipment: vacuum cleaner (fitted with a high efficiency particle air filter on the exhaust), water, high- and low-pressure sprayer, power or fuel for sprayer, plastic sheeting (> 2 mil. thick), long-handled scrubbing brushes, sponges, buckets (pet wash), towels (disposable or cotton), heavy duty plastic garbage bags, berming material (e.g., 4x4s, sand, sand tubes, sand bags, etc.), framing materials to build containment



structures, sump pump and power supply, and drums or plastic totes to contain spent cleaning and disinfection fluids.

- **Disinfectants:** The choice of disinfectants will depend on the particular disease being addressed. State or federal veterinarians could be consulted during the local response planning process to identify specific disinfectants that could be used. Disinfectants can range from dilute solutions of common household products, such as bleach or vinegar to commercially available disinfectants. Broad-spectrum disinfectants, such as Virkon® may be an alternative to identifying and stockpiling multiple types of disease-specific disinfectants. In the Australian Veterinary Emergency Plan (Agriculture and Resource Management Council of Australia and New Zealand 2000), many FADs are reviewed and disease-specific disinfectants are presented. Appendix A briefly describes the disinfectants referenced in Table 1. In addition, the National Biosecurity Resource Center maintains an automated disease-disinfectant search engine housed at the following website: <http://www.biosecuritycenter.org>.

Many disinfectants are corrosive to rubber gaskets and metallic parts in pumps and pressure washers. When finished using this type of equipment, all disinfectants should be removed from the equipment as soon as possible. Most disinfectants will include directions for equipment cleaning with their label instructions. If this information is not present, the equipment should be flushed with several gallons of fresh water followed by approximately one gallon of warm water containing one or two ounces of light mineral oil or liquid detergent (NAHEMS 2005).

2.2.1 Location Criteria

The selection of an appropriate area to establish a disinfection station is critical. The operation of the disinfection station should not negatively impact the environment, and its location should provide easy access for residents and responders.

The following is a checklist of considerations for selecting an appropriate location for a cleaning and disinfection station:

- Adjacent to or part of an existing traffic-control point.
- Generally, flat terrain that is large enough on either side to house the following: disinfection station, water supply, waste water containment, sanitary facilities, parking



for vehicles waiting for disinfection, and those that will not be disinfected. To increase efficiency, responders may not leave the quarantine zone in the same vehicle that transported them through the zone; rather, they will undergo personal disinfection and exit onto the non-quarantine side of the station to acquire transportation away from the response.

- The site should not be located in a sensitive environment (e.g., wetlands, well head protection area, etc.).
- The site should not naturally drain into a sensitive environment.
- The site should have good ground cover to increase infiltration during precipitation and to minimize the potential for creating muddy areas.
- It would be beneficial if the site had access to potable water and a sanitary sewer.
- It would be beneficial if the site were adjacent to an electric power source. The use of a drop service will require coordination with the local power company.
- The site should be on a maintained road or other impermeable surface, preferably with a concrete or asphalt surface.
- The site should be close to sanitary sewers, burial trenches, areas where the surface soil is considered grossly contaminated, septic tanks or manure storages or other areas that could be used to properly dispose of spent disinfection fluid.

The location of a C&D station associated with access control points, temporary animal housing and care, and mortality disposal should be at the entrance to the area. This location should be considered a transition zone from a contaminated area (hot zone) to an area free of contamination (clean zone). First responders call this transition zone a “contamination reduction” zone.

2.2.2 Design

A disinfection station must be designed to provide disinfection at two scales: large scale for vehicles and heavy machinery or construction equipment, and small scale for portable equipment (i.e., cameras, clothing, boots, radios, etc.) and personnel. Regardless of the size of the C&D station, the area around it should be segregated into a clean zone and a hot zone. The hot zone should include the potentially infected or contaminated materials and the actual C&D station entry point and the majority of the C&D station. The clean zone should include all areas known to be free of infection or contamination. The final stages of the C&D station should enter the



clean zone. Potentially infected or contaminated materials should never enter or contact the clean zone.

Small-scale cleaning and disinfection stations should be set up on an impermeable surface, such as plastic sheeting. This will help prevent spent fluids from infiltrating the soil, help contain the spent fluids, and allow for easier clean up of the area. The staging of wash/disinfection stations within this area should provide for gross cleaning and disinfection closest to the quarantine side of the area (hot zone), leading up to a final rinse at the opposite side of the cleaning and disinfection area—the “clean zone.” The area between these zones should be considered a contamination reduction zone.

A small-scale cleaning and disinfection station should provide mechanisms for removing gross contamination and applying disinfectant to equipment or clothing. This type of disinfection area should have three stations. The first station presents the initial cleaning and disinfection step. The second station presents the primary disinfection step. After disinfectant is applied, the clothing or equipment should be set aside for a prescribed period of time to allow the disinfectant sufficient contact time to kill the target bacteria or virus. In some cases, it may be necessary to periodically rewet the materials with disinfectant to keep them from drying out. Between the second and third station, a place should be established to allow disinfected equipment to sit for the required contact time. These times will be dependent on the disinfectant used and the weather. This interim station could be established on plastic sheeting placed between station two and three. The third station provides a final rinse.

Tubs are appropriate for equipment that can be submerged and scrubbed with a cleaner and disinfectant, such as boots or rain suits. Once the equipment has been thoroughly wetted with the initial cleaning and disinfectant solution, it can be scrubbed with a brush to break up any foreign materials that are adhering to the surface. More delicate equipment that cannot be submerged or is otherwise sensitive to moisture can be sprayed with a cleaner and disinfectant and wiped down with disposable towels. Spraying can be accomplished by putting the cleaning and disinfection solution in a hand-operated sprayer (garden-type sprayer) or through the use of



commercial disinfectants in pressurized spray cans. If commercial sprays are used, caution should be taken to select commercial sprays that will not melt or fog plastic, or otherwise damage equipment.

Once the contact time has been reached, the equipment or clothing cleaned and disinfected at the first station should be moved to the second disinfection station. The same procedures applied at the first station are repeated at the second. After the equipment or clothing disinfected at the second station has reached the required contact time, it can be moved to station three where it should be rinsed with clean water. While this rinse water should not contain any live organisms, viruses or spores, it should be treated in the same manner as the other spent cleaning and disinfection fluids. Decisions regarding the need to containerize spent fluids from the small-scale cleaning and disinfection stations should follow the same rationale as described below for the large-scale cleaning and disinfection stations.

Trash receptacles should be placed alongside the first two stations to allow disposable items to be discarded and contained.

The design of a vehicle and heavy machinery cleaning and disinfection station will be dependent on whether spent cleaning and disinfection fluid must be contained pending analysis or some other criteria. The chemical make-up of the decontaminant and disinfectant, its biodegradability, the disease(s) being addressed, the amount of organic matter potentially suspended in the spent fluid, and the influence of public perception issues will all be considered when determining the need to contain the spent fluids. This determination will be made through consultation between MDA (state veterinarian) and Missouri Department of Natural Resources (MDNR). To facilitate response planning, local response personnel should work with local veterinarians and state personnel to select a range of appropriate general purpose disinfectants and determine how the spent fluids will be handled.

The vehicle and heavy machinery cleaning and disinfection station should be designed to efficiently deliver and direct a cleaning and disinfection solution to all areas of equipment or



vehicles that have been exposed to a contaminated environment. In addition, it will be necessary for the cleaning and disinfection equipment to be able to dislodge soil, bedding, manure or other potential contaminated matter from the exterior of vehicles or equipment. Generally, this will be accomplished through the use of low-pressure sprayers and scrubbing brushes. If a target disease can spread in an aerosol form, the use of high-pressure sprayers, with water alone, is not recommended. High-pressure water spray into grossly contaminated foreign matter (e.g., soil, manure, bedding, etc.) can move the disease agent into an aerosol form, increasing the potential for spreading the disease. A mix of water and disinfectant should always be used with high-pressure sprayers.

Gross contamination should be removed at the farm or location where the vehicle or heavy equipment was grossly contaminated. The incident commander should be consulted prior to establishing the vehicle and heavy equipment cleaning and disinfection station at access corridors. They can assist with determining the risk associated with the use of high-pressure sprayers.

Similar to the smaller scale cleaning and disinfection station, it will be necessary to keep the disinfected areas wet until the appropriate contact time for the disinfectant has been reached. To increase throughput for this stage of cleaning and disinfection, it may help to provide a holding area where disinfected vehicles or equipment can wait until contact times have been reached. This will allow the physical cleaning and initial disinfection to continue at a faster pace.

Generally, it is preferable to set up a large-scale cleaning and disinfection site with the intent to containerize the spent fluids and other matter removed from the vehicles and equipment. This will prevent the work area from becoming a quagmire, and it will help reduce impact on the environment. To do this, it will be necessary to build a bermed area that drains into a corner containing a sump from which the spent fluids and material can be pumped into a holding tank. Berming can be constructed from sandbags, posts, straw bales or other available material. The berming on the entrance and exit side should be constructed to withstand vehicle or equipment weight. Ramps should be constructed to protect the berms at the entrance and exit. The



containment area must be covered with an impermeable material to prevent the fluids from infiltrating into the soil. The dimensions of this containment should be made at least twice as big as the largest vehicle or equipment expected to be disinfected. The additional size will allow adequate working room for cleaning and disinfection personnel.

An alternative to creating a bermed area would be to use a front-end loader, bulldozer or road maintainer (grader) to cut a 10- to 12-inch deep depression in the soil. This depression, when lined with plastic to eliminate C&D water infiltration, provides a containment option that will not require a ramp.

When dealing with heavy vehicles and equipment, making the area impermeable can be challenging. Initially, the area must be cleared of all loose debris or objects that could puncture any liner material used. In one corner of the area, a sump pit should be excavated. This pit should be large enough to hold a sump pump and 10 to 20 gallons of liquid. The pit should be located along an edge of the area. Building a bermed area on one travel lane of an engineered road will produce a natural drainage toward the edge of the area, assuming the road has the typical crowning at the center. If the area does not naturally drain to this point, a layer of sand should be put down, with a slope or drainage toward the sump. If a natural containment is used, cutting a depression into the existing ground surface, the grade must be surveyed to assure that water will be contained and that water trapped by the containment accumulates in a corner or in a sump, allowing the fluid to be collected and stored pending a disposal determination.

For either containment option, on top of the soil or sand, one or more layers of plastic sheeting or liner material should be put down to make the area impermeable. Thinner sheeting or liner material will require multiple layers to ensure continued impermeability. To further protect the impermeable layer, plywood sheeting should be placed on top of the material to minimize the impact of vehicles and equipment, and disinfection personnel walking on the material. The heavier the vehicles or equipment, the thicker the plywood needed. Generally, a single layer of 0.5-inch plywood will be appropriate for passenger vehicles. As the size and weight of the



vehicles being cleaned and disinfected increase, thicker plywood or multiple layers of thinner plywood will be required to protect the plastic liner.

Along with this containment base, the large-scale disinfection area will need some form of structure to contain spray drift and splash. This can be assembled by framing a wall around the containment base. The framing should be covered with plastic sheeting to contain the spray drift and splash. This wall should be at least as high as the tallest vehicles being disinfected. The walls on the two ends will need to be moveable to allow vehicles to enter and exit. If high-pressure sprayers are used, these walls may need to be taller to contain the spray drift, or a roof will need to be constructed to contain any spray drift.

2.2.3 Methodology

In its most simple form, C&D can be broken down into these five steps: (1) dry clean (remove gross contamination – solids), (2) wet wash, (3) rinse, (4) dry, and (5) disinfect. The first three steps are critical to remove any organic matter and expose surfaces for disinfection. The fourth step reduces the potential for dilution of disinfectants; however, allowing a vehicle or piece of equipment to drip-dry will not leave sufficient water to cause significant dilution of disinfectants (NAHEMS, 2005). A critical aspect of Step 5 involves the application and maintenance of the disinfectant. The application of the disinfectant should be done according to label directions. Disinfectant contact time should be observed carefully and address the time a surface remains wet with the disinfectant. A surface to be disinfected should remain “shiny” wet for at least 10 minutes; merely damp is not adequate. Some disinfectants require longer contact times (see Appendix A). The contact time for foaming disinfectants is sometimes easier to monitor as is its coverage on the potentially contaminated surface. Porous and rough surfaces will require more disinfectant than smooth surfaces. A heavy application of disinfectant that runs off and puddles on the floor is not effective or efficient. Multiple light applications of disinfectant is one way of keeping the surface wet for the required time.



Cleaning should start at the top of an object and move downward. Detergents should be allowed at least 10 minutes to penetrate organic matter and soil. This penetration will assist the detergent in loosening the material. Once the material is loosened, object should be rinsed with the low pressure washer. After rinsing off all the organic matter, soil and detergent, the object should be allowed to drip dry for at least five minutes before being disinfected.

At the conclusion of each step, C&D personnel must inspect the object being cleaned and disinfected to determine if the actions conducted during the step were effective. If they were not, the step should be repeated.

When a vehicle or heavy equipment approaches the access corridor from inside the quarantine zone, it will be inspected for external sources of contamination (e.g., manure, mud, soil, bedding, etc.). If the vehicle is grossly contaminated, it may be turned away and the occupants will be directed to return to the place where it became contaminated for cleaning to remove the gross contamination.

If the cleaning and disinfection personnel deem the vehicle free enough of contamination to enter the cleaning and disinfection area, it will be driven into the area. At this time, the occupants will be asked to move to an adjacent staging area while the vehicle is cleaned and disinfected. After the exterior of the vehicle or heavy equipment has been cleaned and disinfected, its interior will be inspected for contamination. If necessary, the interior will be cleaned and disinfected as practical. The interior of the vehicle, carpeting, floor mats and pedals should be washed with a detergent cleanser, wiped clean, and then wiped with a cloth soaked in disinfectant (NAHEMS 2005). Any other surfaces inside the vehicle that have visible organic matter or soil contamination should be cleaned and disinfected in the same manner. If the interior or exterior cannot be cleaned or disinfected to the level required, the vehicle should not be allowed to pass through the access corridor. After the interior and exterior have been cleaned and disinfected, the vehicle will be moved to a holding area to allow sufficient contact time for the disinfectant to be effective. During this time, the vehicle will be monitored to make sure it does not dry off. If areas are drying, they should be sprayed with disinfectant using hand-held sprayers.



While the vehicle is being cleaned and disinfected, the occupants will be inspected. The incident commander will develop an exit cleaning and disinfection procedure for residents leaving infected premises, and for any possessions or tools they plan to bring out of the quarantine zone. The occupants will be questioned about their implementation of this plan. Boot washes will be available if supplemental disinfection is required. If the occupants have not implemented the incident commander's plan, they will not be allowed to pass through the access corridor until they have followed the exit plan developed by the incident commander. A typical plan might include the following procedures for personal disinfection, particularly if there has been contact with livestock or contaminated areas.

Residents from an infected premise or a contact premise and responders who become grossly contaminated will need to wash and disinfect themselves and their clothing before they leave the infected premises. Showering and changing into clean clothing may be acceptable for residents not associated with an infected premise or contact premise, but inside a control area. Use of the following substances as personal disinfectants can be recommended where no other approved disinfectant is available:

- Domestic washing soda (10 parts in 100 parts hot water)
- Soap (or household detergent) and hot ($\geq 140^{\circ}\text{F}$) water for scrubbing
- Household concentrated chlorine bleach (1 part in 3 parts water to give 2 to 3% available chlorine). **This must not be used on hands, face or skin.**

Personal Cleaning and Disinfection

The following procedures can be used for response personnel and residents on infected premises and contact premises before leaving a control area. Residents from non-contact premises, especially those with no susceptible animals, may be allowed to exit the area if they shower and wear clean clothing. The exact procedures for these individuals will be determined based on the disease, climate and local demographics.



For personnel and residents who are from infected premises or contact premises, and any others who are believed to be potentially contaminated with the FAD agent, on arrival at the disinfection station, a disinfectant solution, safe for skin contact, should be ready in buckets and sprayers. Since there are no antiviral disinfectants that are both effective against all virus families and approved for use on human skin, warm soapy water is recommended for washing face, hair, skin, etc. To increase the virucidal effect of this type of solution, the pH can be raised by adding sodium carbonate or lowered by adding acetic acid. The direction of the pH shift will be determined by the virus in question. If other skin decontaminants are used, responders must be sure they are effective virucides for the target virus. Heavy-duty plastic garbage bags should be used for disposable items or for items to be removed from the site for further disinfection and cleaning.

Reusable clothing, such as rain suits, can be cleaned and disinfected at this station by using a combination of a sponge, scrubbing brush and a low-pressure sprayer. These items in combination with the appropriate disinfectant should be used to wash the clothing thoroughly, removing gross contamination. This cleaning must target the entire garment, including areas under the collar, zips and fastenings, and the insides of pockets. In most cases, jackets, pants and boots will have the disinfectant applied through immersion in a disinfectant solution. A sprayer would be appropriate if an initial cleaning and disinfection was needed prior to taking off the protective clothing. In this case, the clothing would be grossly contaminated with organic matter. If underclothing has been contaminated, especially above boot level, it must be removed and placed in a plastic bag, the skin washed, and a clean pair of overalls worn for leaving the site.

Reusable clothing, such as coveralls, can simply be removed, soaked in disinfectant, squeezed out, and placed in a plastic bag for C&D. Underclothes and rubber boots should be similarly treated. Plastic bags containing used clothing should be sealed, wiped down with a disinfectant, and placed at the outer limit of the area for collection by courier for laundering. It is best if reusable clothing is disinfected and laundered at the access corridor.



Disposable clothing (i.e., Tyvek® coveralls and gloves) and equipment should be removed and directly placed in plastic bags for disposal.

Once contaminated outer clothing has been removed, personnel should then shower with an appropriate disinfectant, exiting the shower into a “clean” area where clean clothing and footwear is available. After putting on the clean clothing, the personnel can leave the area.

NAHEMS 2005 recommends that even after complete personal disinfection, persons who leave an infected premise must not come into contact with any susceptible animals for at least five days.

Cleaning and Disinfection in Emergency Medical Situations

If a person in the infected zone, from an infected or contact premise, is injured or becomes seriously ill, every effort must be made to aid and obtain medical care for the person as quickly as possible. The very nature of a FAD response means that there is a risk of transporting the infection with the injured person. If it is necessary to initiate an emergency transport of someone out of the infected zone, for example, the level of initial C&D of a person injured will vary with the seriousness of the injuries. Human life is a priority and every measure must be taken to minimize discomfort or pain. If C&D procedures for the person and vehicle must be abbreviated due to the extent of an injury or medical condition, the risk of spreading a disease could be great. In this case, the EOC must be notified. The EOC will then notify the appropriate hospital authorities of the risk and of the appropriate personal disinfection for the patient and vehicle, which should be carried out as soon as circumstances permit.

To minimize the potential to spread a FAD during an emergency transport situation, the following steps should be taken as soon as arrangements for an ambulance or other vehicle have been made (NAHEMS 2003a):

- The Incident Commander should be notified of the incident.



- An individual experienced in biosecurity and cleaning and disinfection procedures should be sent—along with cleaning and disinfection supplies—to meet the emergency vehicle at the medical facility.
- The Incident Commander or a designee should inform authorities at the medical facility of the risk of FAD transmission and ensure that cleaning and disinfection procedures for the patient and medical personnel are initiated as soon as appropriate.
- The patient’s clothing and any of the medical personnel’s clothing that may have become contaminated should be sealed in a plastic garbage bag. Disposable clothing can be worn by the emergency personnel and the victim to minimize the potential spread of contamination. Potentially contaminated clothing should be (a) discarded safely or (b) removed from the bag and laundered, with care taken to dispose of the contaminated bag safely. Any contaminated medical equipment should be cleaned thoroughly (if possible, autoclaved) and disinfected with an approved disinfectant.
- Any surface—inside or outside the medical facility—that may have become contaminated should be cleaned thoroughly and disinfected with an approved disinfectant.
- The emergency vehicle should be cleaned and disinfected, including the interior, underside, wheels and wheel wells.
- Any clothing or boots of emergency vehicle attendants, orderlies or other personnel that may have become contaminated should be removed, sealed in a plastic garbage bag, and laundered, dry cleaned or disinfected with an approved disinfectant or discarded.

Vehicle and Heavy Equipment Cleaning and Disinfection

The following procedures can be used to clean vehicles and equipment (i.e., cars, livestock carriers, feed trucks, milk trucks, carcass transporters, airplanes, etc.) that leave an infected zone. All of these vehicles have the potential to spread a contagious disease out of the quarantine area. If at all possible, the movement of vehicles out of the infected zone should be minimized. Clean vehicles should be available for responders to use after they have undergone the personal cleaning and disinfection described above.

Cars, pickup trucks and other personal use vehicles can be cleaned and disinfected using the following procedures. All floor mats should be removed for scrubbing with disinfectant. The inside of the vehicle that has had contact with passengers or the driver (e.g., dashboard, steering wheel, handbrake, gear shift and seats) should be wiped liberally with appropriate disinfectant. If the trunk or bed of a truck is considered contaminated, the contents must be removed and the



interior of the trunk or truck bed wiped with disinfectant. The contents of the trunk or truck bed must be disinfected before being replaced, or they can be left in a secure location inside the quarantine area. The wheels, wheel wells and underside of the car should be sprayed with disinfectant and all foreign material (e.g., soil, manure, bedding, etc.) must be removed. In some cases, it will be necessary to clean and disinfect the entire outside of the vehicle if it is visibly contaminated or it has come from infected premises.

Plain water should not be used with high-pressure sprayers, because the process could release mist and aerosols containing the disease agent. This can lead to the spread of a disease. A mixture of disinfectant and water should always be used with high-pressure sprayers. Generally, cleaning and disinfecting grossly contaminated vehicles should only be done on the premises where they became contaminated. Doing this gross cleaning at the access corridor raises the possibility of unintentionally spreading the disease.

Cleaning and disinfecting grossly contaminated vehicles by brushing with a combination of a disinfectant and soap, to dislodge encrusted dirt and organic matter, is preferable to washing with high-pressure water streams.

Vehicles used to transport livestock and poultry will need to be cleaned and disinfected if they are to leave a quarantine area. The gross cleaning and disinfection should not be carried out at an access corridor; rather, it should be conducted at the location where the trailer is unloaded, inside the quarantine zone. The gross cleaning and disinfection should involve removing all foreign matter (e.g., soil, manure, bedding, etc.) from trailers and bodywork. Vehicles should then be soaked in detergent and disinfectant and scrubbed down to bare metal, painted surfaces or wood with a detergent and disinfectant. Fixtures and fittings should be dismantled to ensure that infected material has been removed. Wooden surfaces must be cleaned and disinfected, where appropriate, before removal and disposal. When the crate structure of a trailer has been cleaned, it should be lifted, if possible, from the chassis so the undersides and mounting points can be cleaned. Livestock or poultry transport vehicles must be closely inspected to check whether there are double layers of metal or wood used in their construction. If there are two



layers, the top layer should be removed to reach areas where contaminated material could be trapped. Any metal flooring that appears solid should be checked to be sure there is no foreign material under the flooring. Some trailers may carry extra equipment under the chassis, which must be cleaned and disinfected. Outer wheels and spare wheels must be removed to ensure adequate cleaning and disinfection and to inspect the spare wheel hangers that can be hollow, which creates a potential to contain contaminated material.

The driver's cab and, where fitted, the sleeping compartment must be thoroughly cleaned and disinfected. The driver should be questioned as to the disposition of clothing and boots worn when in contact with diseased livestock or poultry. This clothing should be cleaned and disinfected.

Specialized stock vehicles may carry their own water, food and litter supplies for the animals. Water, feedstuff and litter carried in the vehicles must be disposed of. Burning or burial are common methods of disposal for these materials.

If dairies are situated in the infected zone, it may become necessary to clean and disinfect milk trucks if it is essential for them to leave the control area.

Disinfectants used on the inside of the milk tank must not leave a chemical or taste trace. If a tanker is carrying infected milk, the volume of milk must be determined and the milk mixed with the correct strength of disinfectant. It must be left standing for the appropriate contact time and then disposed of appropriately. The appropriate disposal of contaminated milk, if relevant to the county, should be determined in the emergency planning stage of response preparedness. The exterior and interior of the tanker must be cleaned, along with all hoses and fittings. The procedures for general cleaning and disinfection follow the procedures discussed for livestock and poultry transport vehicles.

Feed trucks may need to enter and exit the infected zone to service non-susceptible animals, infected animals or other susceptible animals in the zone. If it is necessary to allow a feed truck



into a quarantine zone, a specific route should be planned to minimize the potential for contamination of the vehicle. Wherever practical, animal feed should be delivered to the outer limits of a property and then transferred to the animals, so the vehicle and driver do not become grossly contaminated. The vehicle and driver must be thoroughly cleaned before being allowed to leave. Feed truck cleaning and disinfection will follow the procedures discussed for livestock and poultry transport vehicles. In addition, residual feed in the vehicle must be sprayed with disinfectant and removed for disposal. The insides of bulk trailers should be cleaned with approved disinfectant.

If a quarantine zone encompasses an airport, potentially contaminated aircraft should be cleaned and disinfected before being allowed to leave the area. Aircraft construction prohibits the use of strong alkaline disinfectants, including caustic soda, because of corrosion problems with metals, such as aluminum. A mild alkaline disinfectant, such as sodium carbonate, can be suitable for use on aircraft. Care is required when disinfecting specialized equipment in the aircraft.

Heavy machinery used on an infected premise will be grossly contaminated. Machinery may include excavators and backhoes, bulldozers, front-end loaders, forklifts, tractors/trailers, dump trucks, fire trucks (incineration monitoring), roll-offs, cranes, chains, hooks, shovels, cargo nets, etc. This equipment must remain on the contaminated site until needed elsewhere. For example, this machinery must be cleaned and disinfected once carcass disposal has been completed and prior to moving to another site within the infected zone. This gross cleaning and disinfection should follow the guidelines discussed above for livestock and poultry transport vehicles, but this should be conducted at the contaminated site where the equipment had been used. When a vehicle has undergone gross cleaning and disinfection and it needs to be moved out of the quarantine zone, it should be moved to the access corridor for final cleaning and disinfection.

Portable Equipment Cleaning and Disinfection

If electrical equipment, such as generators or motors, must be moved out of an infected zone, the following procedures can be used. If there is doubt, consult an electrical contractor. Consider



whether cleaning this type of equipment is a priority. It is unlikely that covered electrical equipment will be heavily contaminated. These items are best considered at the end of the cleaning process, when specialists can be more readily consulted.

The most practical method of cleaning involves placing the equipment inside an airtight enclosure, possibly constructed from plastic sheeting, for fumigation. If the equipment can be easily dismantled, it should be, and then all of its parts should be placed in a small enclosed space for fumigation. Some electrical items may be inherently airtight, in which case they can be safely cleaned and disinfected by wiping down with disinfectant. A possible fumigant is formaldehyde gas. Serious consideration must be given to the practical and safety aspects of this procedure. It is important to remember that most viruses will inactivate spontaneously with time. Exposure to the ultraviolet light in sunlight may be another option for disinfecting complex equipment.

Hand-held radios, cameras, tape recorders and clipboards are a few of the portable types of equipment that will be used inside a quarantine zone. All of these items can be used while protected inside plastic bags. Inexpensive waterproof cameras can be used to record response actions. The waterproof nature of the camera will allow it to be disinfected. When it is necessary to remove this type of equipment from a quarantine zone, the following procedure should be completed at the small-scale cleaning and disinfection station at the access corridor:

- Wipe protective plastic bags with disinfectant and discard them.
- Wipe the body of the equipment with disinfectant.
- Place equipment in a clean plastic bag for removal.

There is a small residual risk of contamination; therefore, these items should only be used in a specific quarantine zone for the duration of the outbreak.



Equipment used to euthanize livestock (i.e., captive bolt guns and firearms) is generally considered to be grossly contaminated. After use, these devices should be cleaned and scrubbed with disinfectant at the location where they were used and again at the access corridor.

Ground Surface Disinfection

Outdoor ground areas where people, equipment and vehicles pass should be disinfected in cases of a FAD outbreak. Asphalt, concrete or similar substances can be treated with sodium hydroxide, potassium hydroxide, or sodium carbonate. On soil, calcium hydroxide may be applied in addition to the alkaline solutions mentioned above. In extreme cases, the upper surface layer of soil should be removed and or covered by asphalt, concrete or other appropriate surface material (NAHEMS 2005).

3.0 PERSONNEL

C&D is the primary tool responders have to limit the potential of FAD spread from infected animals. In addition, the potential for contamination will be greatly reduced if only essential personnel and equipment are brought into the quarantine zone or the temporary housing and care area. To reduce the cleaning and disinfection necessary at these sites, vehicles should not be brought into the sites.

Personnel conducting C&D activities should have a broad knowledge of FADs, and the general nature of cleaners and disinfectants. Generally, staff working at cleaning and disinfection sites will require training in operation and maintenance of disinfection or cleaning stations, biosecurity, and FADs. Local veterinary staff can provide training in the latter two areas. The training will allow these personnel to make informed decisions regarding the need for and adequacy of disinfection, and the background to identify possible disease spread vectors inside vehicles or otherwise associated with the travelers.



Often, local fire and rescue personnel have had training in cleaning and disinfection. Other personnel may be obtained from the following organizations: county roads, public works department, Missouri Regional Hazmat Teams, Missouri Department of Transportation, the Missouri National Guard, local citizen's corps, or other organizations with appropriately trained personnel.

4.0 BIOSECURITY

In order to preserve herd or flock health and prevent the spread of disease, local emergency planners should develop biosecurity guidelines for responders. All personnel associated with the response should be required to conform to the county's biosecurity guidelines. Possible biosecurity guidelines should include the following:

- Workers may be required to wash and disinfect their vehicle or tires prior to entering area. State or federal veterinarians should be consulted on the need for this level of biosecurity.
- Workers should be required to sign in, in order to track all personnel in the area.
- Workers should be required to maintain, at a minimum, a 48-hour animal-free period after coming offline from a response shift. Visits to state fairs, zoos and other places where animals are housed must be figured into the animal-free day calculation. In the case of poultry, response personnel must eliminate contact with pet birds (even being in the same house) or other bird-gathering areas, such as feeders. Depending on the species involved and the potential risk, these animal-free periods can be modified, especially if unique crews can be assigned to each area.
- Workers should be required to wear clean clothes, which typically include coveralls, head covering and boots.
- Workers may be required to shower before entering and prior to exiting the area. If this is done, local emergency planners must provide the supplies and equipment necessary to support this option.
- Workers should disinfect portable equipment prior to entering the area.
- Workers should not wear jewelry.
- Workers should work on animals from youngest to oldest when phases of production are collocated. Veterinarians should be consulted on this order for the various species considered.
- Workers should utilize the boot disinfection stations provided.



5.0 HEALTH AND SAFETY

General first aid and access to emergency medical services must be provided for all FAD response activities. This portion of a response would be coordinated by the Safety Officer, a member of the Command Staff supporting the Unified Command.

Cleaning and disinfection area personnel should be provided PPE to minimize their exposure to contaminated materials and to facilitate cleaning and disinfection. Unless stipulated by the Safety Officer, respiratory protection may not be necessary. Cleaning and disinfection workers should wear waterproof clothing or rain suits, with hoods, that can be disinfected and reused. Rubber gloves and rubber boots also will be needed. These items can be disinfected and reused. Under gloves, cotton or nitrile, should be worn inside the outer rubber glove. The personnel also should wear hardhats fitted with face shields to protect their faces. In addition, dust masks can be worn to protect the workers' mouths and to prevent ingesting splashed materials.

Personnel working at a C&D location should be aware of the dangers associated with handling livestock. In addition, they may be provided PPE to minimize their exposure to the animals. While most of the FADs that may be encountered are not zoonotic, the use of some level of PPE is still necessary to maintain personal hygiene and facilitate C&D upon leaving the C&D area. In the event a FAD response has the potential to expose workers to possible infection, PPE will be used to provide both dermal and respiratory protection. The Safety Officer and the State Veterinarian will determine the need for and specific types of PPE.

Generally, C&D workers should wear disposable clothing or clothing that can be disinfected and reused. Synthetic (rubber or nitrile) gloves and rubber boots also will be needed. These items can be disinfected and reused. Under gloves, cotton or nitrile, should be worn under the outer synthetic glove.

Dust masks can be worn to protect the workers' mouths, preventing the possible ingestion of splashed materials. Generally, dust masks only provide protection against nuisance conditions



and do not provide true respiratory protection. If the FAD is zoonotic, increased respiratory protection may be needed. Generally respiratory protection may be provided by a disposable filter-type respirator, a full or half-face respirator with the appropriate filter cartridge or a powered air-purifying respirator with the appropriate cartridge. The proper use of any type of air purifying respirator will require a successful fit test for the user and the specific respirator being used. The criteria for a successful respirator fit test are defined in guidelines produced by the Occupational Safety and Hazard Administration. Cartridge selection should be based on the type of respiratory protection required.

According to NAHEMS 2005, all responders associated with a FAD emergency who use PPE must:

- Understand why they need PPE (i.e., appreciate the importance of PPE in minimizing the spread of the disease agent and in preventing occupational injuries and diseases).
 - Understand why PPE and devices are being used as a substitute for—or as an adjunct to—other hazard control methods.
- Understand the consequences of unprotected exposure and thus the rationale for compliance with proper procedures for the use of PPE and devices.
- Learn to recognize when equipment is not functioning properly so that it can be repaired or replaced as needed.
- Be able to inspect, fit-test, don, remove, clean, replace as necessary, and maintain PPE and devices.
 - Appreciate the importance of the “buddy system” in using PPE and devices safely and effectively.
- Understand the limitations of PPE, particularly in emergency situations.

The use of PPE should be evaluated in conjunction with worker safety related to conducting their appointed duties while wearing PPE. PPE increases the physical and psychological stress associated with response work. A responder’s manual dexterity, agility and stamina are generally impacted by the need to use PPE. Heat-related illness and fatigue are common side effects of wearing PPE. Much of this secondary effect is weather related. The use of PPE in hot weather may necessitate frequent breaks to protect worker safety. The use of a respirator can cause feelings of claustrophobia, create communication difficulties, and impair vision.



Appendix E presents general PPE guidelines in the NAHEMS operational guidance manual on PPE.

6.0 COMMUNICATION

Due to the dynamic nature of an emergency response to a FAD, the establishment and maintenance of cleaning and disinfection facilities must be coordinated with the ever-changing understanding of the nature and extent of the disease in question. In order to allow the teams in charge of cleaning and disinfection areas to quickly respond to changing field conditions, communication between the teams and the EOC or incident command post must be maintained. Real-time communication and pre- and post-shift meetings constitute the required communication needed to support cleaning and disinfection areas.

7.0 DOCUMENTATION

Throughout the process of conducting cleaning and disinfection, it will be necessary to provide various types of documentation. For reimbursement payments to the responding agency or cost sharing, it will be necessary to document the resources applied and expended in cleaning and disinfection. These costs can include labor charges, equipment rentals or purchase, costs of expendable equipment or supplies, subcontractor costs, or any other costs associated with providing the cleaning and disinfection services.

Because of the nature of an emergency response, it is critical to identify personnel who will have the responsibility of documenting these issues or monitoring and verifying that other parties are collecting the needed documentation. In some cases, identifying a specific response job that includes documentation will be preferable, especially if personnel will be rotated through shifts and response jobs. This role and responsibility should be identified and described in a county's LEOP.



Possible actions or items that should be included in a documentation checklist include:

Responder time (hours)	Meals provided
Number of responders	Location of each responder
Identity of responders	Equipment at each point
Sanitation services provided	Usage time for equipment
Water provided	Specific quantities of expendables used
Number of people/vehicles cleaned	

Documentation also will be essential to tracking vehicles, heavy equipment, and people who exit and enter the area.

Documentation should be maintained in written form. Video, photographs and tape-recorded messages can be used to supplement the written documentation. Written documentation can be maintained in a logbook, or by using documentation worksheets, or a combination of both. Documentation should be recorded with an ink pen, and any entry errors should have a single line drawn through them with the author's initials and date recorded at one end of the line. If a logbook is used, it should have numbered pages and the spine should be sewn, making the removal of pages both difficult and obvious. Pages should never be removed from a logbook. Anyone making entries in the logbook should sign and date the bottom of each page. If documentation worksheets are used, the author should sign and date the bottom of each worksheet. Sets of logbooks and worksheets should be assigned to each response task (i.e., traffic control, cleaning and disinfection, mortality disposal, etc.) or a master set of logbooks and sheets can be maintained. Logbooks and worksheets should be assigned unique identification numbers. When the logbooks or a group of worksheets is issued from the EOC to a responder, the identification numbers of the logbooks and worksheets should be recorded and the recipient should sign them out in a document-tracking log maintained by the EOC. This establishes a chain-of-custody for the documentation.

If pictures, video, or taped messages or interviews are used to supplement the written documentation record, the following information should be documented for each picture, video segment, or audio-taped message or interview: photographer or interviewer, subject, time, date,



person interviewed (video or audio taped), photo and film roll number, direction (pictures and video), and general weather conditions (i.e., temperature, wind direction, humidity, sky condition, etc.).

8.0 TRAINING

Personnel staffing the cleaning and disinfection station would benefit from training in: the operation and maintenance of the cleaning and disinfection equipment; disinfection procedures; associated environmental protection issues; and the inspection of people, vehicles, pets and other possessions prior to crossing the access corridor. The latter training will require basic training in biosecurity and FAD. Some of these requirements are addressed in MDA SOG No. 003, *Temporary Housing of Livestock and Poultry*, Section 2.3. In addition, C&D staff should be trained in the physical, chemical and biological hazards associated with their job.

Qualified state and federal employees could be utilized to develop and provide this training for responders that might be assigned these tasks. The incident's health and safety officer could provide health and safety briefings.

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APPENDIX A
DISINFECTANTS

DISINFECTANTS

Table 1 presents some common FADs that could be encountered during an emergency response to a livestock or poultry disease outbreak. This Appendix presents a brief description of the classes of disinfectants mentioned in Table 1, and other information, such as general contact times. This appendix begins with a brief discussion of physical disinfection methods. This information was adapted from NAHEMS 2003. The second section of this appendix focuses on chemical disinfectants. Chemical disinfectants will be the most common disinfectants used in a large-scale FAD response.

Table 1
Common Contagious Animal Diseases

Disease	Species affected	Transmission	Best Disinfectant
African Swine Fever	Swine	Ingestion, contact, ticks	Category A
Influenza (avian, equine, swine)	Birds, horses, swine	Aerosols, ingestion	Category A
Newcastle Disease	Birds	Aerosols, ingestion	Category A
Renderpest	Ruminants, cattle	Aerosols, ingestion	Category A
Peste des Petis	Small ruminants	Aerosols, ingestion	Category A
Foot-and-Mouth Disease	Cloven hoofed animals	Aerosols, ingestion	Category B ¹
Swine Vesicular Disease	Swine	Aerosols, ingestion	Category A
Classical Swine Fever	Swine	Contact, ingestion	Category A
Porcine Respiratory and Reproductive Syndrome (PRRS)	Swine	Contact, aerosols	Category A

Notes: This information was adapted or modified from the AUSVETPLAN, 2000 (Agriculture and Resource Management Council of Australia and New Zealand, 2000) and NAHEMS 2003 and 2005.

A Best disinfectants are detergents, hypochlorites, alkalis, Virkon®, and gluteraldehyde.

B Best disinfectants are hypochlorites, alkalis, Virkon®, and gluteraldehyde. Bactericides, like quarternary ammonia compounds and phenolics, are not effective against these viruses.

¹ Acids also are effective for Foot-and-Mouth virus.

Responders seeking United States Environmental Protection Agency (EPA)-registered disinfectants against animal pathogens should contact EPA for an up-to-date list. In some cases non-registered disinfectants may be used if they have been given a Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Section 18 exemption from EPA (NAHEMS 2005).

SECTION 1: PHYSICAL DISINFECTING AGENTS

Heat: Can impact the efficacy of many disinfectants. As temperature increases, the rate of chemical reaction increases. This increase in activity results in most disinfectants working better at higher temperatures.

Moist Heat: When heat is used for disinfection purposes it can be applied most effectively by using hot water or steam. All vegetative microorganisms can be killed by 176° F (80°C) for 10 minutes. Anthrax spores will be killed by 212° F (100°C) for 10 minutes but *Clostridium botulinum* and *C. subtilis* spores withstand boiling for hours.

Pasteurization: Is an application of moist heat. Pasteurization does not kill all of the microorganisms in milk or other liquids. It is intended to reduce the bacterial contamination and, in the case of milk, to kill *Mycobacterium bovis*, *Brucella abortus*, and *Salmonella sp.* without altering the flavor or nutritional quality of the milk any more than necessary.

Autoclaving: An autoclave uses pressure to increase the boiling temperature of water. Water boils at 212° F (100°C) at sea level, while at 15lb/in² (~1 Atmosphere of pressure), it boils at 250° F (121°C). The higher temperature and moist heat significantly reduces the time necessary to penetrate any porous materials in the autoclave and kill microorganisms.

Dry Heat: The use of flame or baking is less effective than moist heat for disinfection. Vegetative microorganisms are more resistant to dry heat than they are to moist heat and spores are even more resistant. Some examples of the application of dry heat would include the incineration of carcasses or other biomedical waste, the heating of a bacterial loop in a Bunsen burner flame, the searing of a surface before sample collection, and the cauterizing of a wound.

Ultraviolet Light: Ultraviolet (UV) light is a non-ionizing radiation produced by sunlight or mercury vapor lamps. UV light disinfects by damaging cellular DNA. UV light produces primarily a surface effect and does not penetrate even a thin layer of protein or pigment. It can

be used as a supplemental disinfection method in clean areas (e.g., surgical suites or media preparation areas) to reduce bacterial burden in the air. UV light can be used to disinfect water if very thin water layers are exposed to the light. Humans and live animals should not be exposed to high levels of UV light because of skin and eye damage.

Filtration: Filters and ultra-filters can be used to remove microorganisms from gases and fluids. Filtration is used for producing clean water in water treatment plants and is nature’s way of cleaning water as it percolates through soil and rock into ground water. Filtering is used to produce microorganism-free solutions when other methods would be detrimental to the product. HEPA filters are used to filter the air for FAD responders and in surgical suites, laboratories, industrial processes, and to assure the safety of air discharged from biologic safety cabinets.

SECTION 2: CHEMICAL DISINFECTANTS

Table 2, found at the end of this section, summarizes the information presented below. Some chemicals in the list below are hazardous and will require special precautions (Table 3, also found at the end of this section). These chemicals should only be used under the supervision of properly trained personnel.

Soaps and Detergents

Soaps and detergents are commonly used to clean the surfaces of contaminated equipment or clothing. As a disinfecting agent, soaps and detergents inactivate the cell walls of bacteria and destroy the envelope of enveloped viruses. Often their primary function is to remove organic matter, soil, grease and other surface contaminants. The use of hot water and physical abrasion (scrubbing) will enhance the soap or detergent’s ability to remove contaminants. The surfactant action of soaps and detergents effectively removes most Category A (see Table 1) viruses from contaminated surfaces.

Many commonly used disinfectants associated with hospitals, dairies and food-processing areas involve soapy combinations of phenolics or quaternary ammonia compounds. These agents are bactericides; however, they have limited use as virucides. While these materials could be used in preparatory cleaning and cleaning, better bactericides and virucides are available that will clean and disinfect at the same time.

Halogens

These agents are commonly recommended as disinfectants, following proper cleaning, for many applications. These agents are highly toxic to aquatic life. These materials should not be discharged into a watershed without proper neutralization. The effectiveness of these solutions is optimal in the pH range of 6 to 9. As the concentration of organic matter increases in the solution, the effectiveness of halogens as a biocide is reduced. These solutions are negatively impacted at temperatures above 60°F; they rapidly decompose and lose effectiveness as a biocide.

A common halogen disinfectant is liquid bleach or chlorine powder for swimming pools (sodium hypochlorite). In a bleach solution, chlorine is released and is a powerful oxidizing agent and capable of killing all virus groups (Nalepa, 2000). Studies have shown that sodium hypochlorite solutions of around 0.18% provide an effective broad-spectrum biocide. Effective hypochlorite disinfecting solutions can be made from household bleach or chlorine powder used to maintain swimming pools.

Calcium hypochlorite and iodine are additional examples of halogen disinfectants. Calcium hypochlorite also is known as chlorinated lime and is mixed at a ratio of one pound to three gallons of water to produce an effective disinfectant. Iodine is relatively insoluble in water. It is necessary to use potassium iodine to dissolve sufficient amounts of iodine in water. Iodine is more effective than the other halogen disinfectants in the presence of organic matter.

Oxidizing Agents

Virkon S® is a commercially available oxidizing disinfectant that incorporates a high percentage of surfactant. This yields a good cleaning product with virucidal properties. It is supplied as a water-mixable powder. This material is reported to have low environmental toxicity. In 1% solution, it has a pH of 2.6 and thus would be effective as an acid disinfectant if this were its only mode of action. Due to its acidity and oxidizing nature, it is effective against all 17 virus families.

The Material Safety Data Sheet (MSDS) indicates that in 1% solution Virkon S® does not irritate the skin or eyes; however, this material is not approved for use on skin. There is no occupational exposure limit specified on the MSDS for the 1% solution. Company literature indicates that at dilutions encountered in normal working solutions, the ingredients are decomposed or biodegraded and are comparatively harmless. The powder is corrosive and will cause skin burns and irreversible eye damage. It is harmful if swallowed, absorbed through the skin, or inhaled. Wear impervious gloves, goggles and respiratory protection when handling the powder. Virkon S® in its powder form should not be subjected to high temperatures because, when heated to 158° F (70° C), it will decompose and create toxic sulfur dioxide gas.

According to company data, the 1% solution has a 10% loss of initial activity after seven days in 350 ppm hard water, and the powder form has a 2.3% loss of initial activity after 36 months at 68° F (20° C). Packages of dipsticks are available to check the strength of working solutions of this product.

Alkalis

High pH materials, alkalis, are effective disinfectants. Alkalis kill most bacteria and viruses when the pH is greater than nine. Alkalis are not effective against spores or non-enveloped viruses. Common alkalis include sodium hydroxide (caustic soda) and sodium carbonate (washing soda). These agents are low cost and have a natural saponifying action on fats, which

can help in the cleaning process. These materials are virucidal, and they maintain their effectiveness even with high concentrations of organic matter. These agents are often used for the disinfection and cleaning of penning, buildings and manure pits associated with livestock or poultry production.

Calcium hydroxide (air-slaked lime) also has been used as an effective disinfectant. However, this disinfectant is not effective against spores. It has been used to disinfect premises. A 20% solution with water is a common strength used for disinfection.

Acids

Acids with a pH below three can be used against bacteria and enveloped viruses. They are not effective against non-enveloped viruses, with the exception of the Foot-and-Mouth Disease virus. When using an acid, it is important to match appropriate acid or mixture with the virus being treated. These agents can be useful in disinfecting a broad range of materials from liquid effluent to personal cleaning. Citric acid and acetic acids are weak acids that can be useful against many acid-sensitive viruses (e.g., Foot-and-Mouth Disease) and are mild enough to be used on clothing and for personal disinfection. In some applications, acids can be added to detergents to combine the cleaning power of the detergent with the disinfecting ability of the acid.

Aldehydes

The aldehydes are effective against bacteria and enveloped viruses. They are somewhat effective against non-enveloped viruses, bacterial spores and acid-fast bacteria.

Gluteraldehyde is a virucide that is effective against all virus families and many other organisms. It is a liquid at room temperature. It is activated as a disinfectant by raising its pH above seven. At a pH above nine, the material decomposes. This agent can be effective at concentrations of 2% and its effectiveness is reduced as concentrations of organic matter increase. Recent studies

have suggested possible negative long- and short-term health impacts associated with the inhalation of gluteraldehyde vapors.

Formaldehyde is a gas at room temperature, and is used as an area disinfectant in poultry houses and incubators. The gas dissolves readily in water to form a solution called formalin, which consists of 37% weight/weight (w/w) formaldehyde in water, with 10% methanol added to improve stability. A 40% aqueous solution of formaldehyde gas is an effective disinfectant. A 1:12 dilution of formalin in water produces an 8% solution that is effective against most virus families, but not against scrapie or bovine spongiform encephalopathy. The presence of organic matter decreases its effectiveness.

Other

NAHEMS 2003 identifies and provides additional detail on surfactants, phenols and coal tar acids, alcohols, heavy metal, dyes and gases as possible disinfectants.

**Table 2
 Disinfectants Effective on Viruses**

Disinfectant Group	Form	Strength	Contact Time (minutes)	Applications
Soaps and Detergents	Solids or liquids	As appropriate	10	Cleaning and disinfection. Can be used on Category A viruses (i.e., lipid-containing virus).
Halogens				
Sodium hypochlorite	Concentrated liquid (bleach)	1:5 dilution (2-3% available chlorine), 1 fl. oz. of household bleach per gallon of water	10-30	Use for most viruses, loses effectiveness as organic matter concentrations increase, rapidly decomposes at temperatures >60°F.
Calcium hypochlorite	Solid	4 oz. per gallon (2-3% available chlorine)		
Oxidizing Agents				
Virkon S®	Powder	3 oz. per gallon (2% weight (w)/volume (v))	10	Active against all virus families.
Alkalis				
Sodium hydroxide	Pellets	3 oz. per gallon (2% w/v), or a 2% solution can be made by mixing 1/3 cup of pellets per gallon of water	10	Very effective on most viruses. Not compatible with aluminum or aluminum derived alloys.
Sodium carbonate	Powder (anhydrous)	6 oz. per gallon (4% w/v)	10	Good when high concentrations of organic matter are expected.
	Crystals (hydrated)	14 oz. per gallon (10% w/v)	30	
Acids				
Acetic	Liquid (vinegar is 4 to 8% acetic acid)	4 to 5 % (6.5 fl. oz. of glacial acetic acid per gallon of water)	Not listed	Not a broad-spectrum virucide (e.g., effective for Foot-and-Mouth).
Citric	Powder	¼ oz. per gallon (0.2% w/v)	30	
Aldehydes				
Gluteraldehyde	Concentrated solution	As appropriate (2% w/v)	10-30	Effective against most viruses.
Formalin	40% formaldehyde	1:12 dilution (8% v/v)		Releases irritating and toxic gas.

Modified from AUSVETPLAN (Agriculture and Resource Management Council of Australia and New Zealand, 2000); and Bayer (1998).

Table 3
Special Considerations When Using Disinfectants

Disinfectant	Health Aspects	Environmental Problems and Other Cautions
Hypochlorites	Toxic for eyes and skin	Strong bleach. Inhibited by high concentrations of organic matter. Corrosive for many metals.
Virkon®	Reasonable care necessary	Corrodes brass.
Sodium hydroxide	Caustic for eyes and skin	Avoid contact with strong acids. Cannot be used on aluminum or like alloys.
Sodium carbonate	Mildly caustic for eyes and skin	Avoid use with aluminum and like alloys.
Hydrochloric acid	Toxic for eyes, skin and respiratory passages	Corrosive for many metals and concrete. Avoid contact with strong alkalis.
Glutaraldehyde	Avoid eye and skin contact	
Formalin solution	Releases toxic gas; irritating for mucous membranes	
Formaldehyde gas	Very toxic for mucous membranes in concentrations down to 2 ppm	Cannot be used in presence of water, hypochlorites or chlorides. Cannot be released to atmosphere without neutralization. Corrosive for some metals.

Modified from AUSVETPLAN (Agriculture and Resource Management Council of Australia and New Zealand, 2000)

APPENDIX B
PPE GUIDELINES
(Adapted from NAHEMS 2005)

PPE for FADs That Have No Human Health Risk Component

Recommended PPE for routine field investigations may include coveralls, a cooling vest, an apron, gloves, boots, eye protection, respiratory protection, and head and hearing protection. If disposable equipment is used, it should not be reused.

Coveralls — Acceptable coveralls for use in a routine field call include: (a) clean, washable, reusable, long-sleeved, one-piece cloth coverall suits or (b) clean, disposable, long-sleeved one-piece Tyvek® coverall suits.

Either type of coverall may be worn over street clothes; however, warm, humid weather conditions may result in some discomfort for the worker wearing long-sleeved coveralls, especially over street clothes. Either white or colored Tyvek® suits are acceptable.

Cooling Vest — If the weather is warm, a cooling vest may be used under the coveralls. Cold weather operations may require additional insulated underclothing.

Apron — An apron should be used to prevent gross contamination of coveralls when conducting work that could result in this level of contamination (i.e., cleaning and disinfection, post mortem examination, etc.)

Gloves — Appropriate gloves should be considered standard PPE for routine FAD calls. Standard disposable latex gloves are recommended for clinical use in the field. Gloves made from other materials may be substituted for latex gloves under certain conditions. Such materials include nitrile, butyl, polyvinyl chloride (PVC), and neoprene, which are available commercially.

Cut-resistant gloves made of materials such as steel mesh, Kevlar®, and Surgipath®, are essential PPE for personnel who are conducting necropsies and collecting and cutting tissue specimens in the field. These gloves should be worn as essential PPE on both hands over the latex or other waterproof gloves and should be disposed of or thoroughly cleaned and disinfected before being removed from the necropsy area.

Boots — For field use, high pull-on boots worn over stocking feet are far preferable to overshoes or overboots, neither of which is recommended. To permit thorough cleaning and decontamination, the boots should be of rubber or plastic waterproof material with shallow treads to permit thorough cleaning. Safety boots with flexible steel toes and midsoles, which provide extra protection from puncture wounds and events involving crushing, are especially recommended for wear in the field.

Eye Protection — Acceptable eye protection in the form of unbreakable, splash-proof goggles or glasses should be worn during a response. A full-face shield may be substituted.

Respiratory Protection — In this instance respiratory protection might be provided to assist workers in dusty environments or relative to preference or comfort issues particular to an individual responder.

Specific types of respiratory protection should be determined by the incident Safety Officer and may range from a dust mask to a powered air-purifying respirator. The use of respiratory protection above a dust mask may require medical monitoring of the wearer. The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor requires that users of filtering respirators such as the N-95® be enrolled in a respiratory protection program that includes pulmonary function testing; medical clearance; respirator fitting and testing; initial and periodic respiratory protection care-and-use training; and medical surveillance. In addition, the user must be clean-shaven.

Head and Hearing Protection — Under certain circumstances, a hard hat and hearing protection may be recommended.

PPE in Settings with Significant Human and Community Health Risk

Examples of FADs with significant human and community health risk include the hanta, hendra, and nipah viruses; Q fever; Rift Valley fever; and Highly Pathogenic Avian Influenza (H5N1). Below is a brief overview of the types of PPE and suggestions for use in situations on premises on which diseases such as these have been diagnosed.

Recommended PPE for visits to settings with significant human and community health risk include coveralls; a cooling vest (optional); gloves; boots; respiratory and eye protection. If disposable equipment is used, it should not be reused.

Coveralls—A clean, disposable, long-sleeved, one-piece Tyvek® coverall suit is recommended for this setting. The visitor should remove all street clothing (both outerwear and underwear, including socks) before putting on the coveralls. If the weather is warm, a cooling vest may be used under the coveralls. Cold weather operations may require use of additional insulated underclothing that is dedicated to use for this purpose. Dedicated socks also should be donned. To ensure complete, thorough personal decontamination, all garments—including coveralls, cooling vest or insulated underwear, and socks—should be removed at the end of the investigation or visit.

Gloves—Double sets of gloves are essential PPE in situations involving disease agents in this risk category.

Double-Gloving—The first pair of gloves that is donned may be nitrile disposable gloves, followed by a pair of thicker nitrile or other rubber gloves. If wearers are working in a potential cut-hazard environment, cut-resistant gloves (e.g., steel mesh, Kevlar® or Surgipath®) may be used as well. If the outer nitrile or rubber glove could be damaged by abrasion, a cotton or leather disposable outer glove should be used.

Taping Cuffs—To prevent the responder's exposure to the disease agent of concern, a tight seal must be made between the cuffs of the coveralls and the cuffs of the gloves. The cuffs of the coverall sleeves should be placed over the cuffs of outer gloves and taped in place with duct or similar type tape. On both sleeves, the tape should be placed so that it extends equal distances over the coverall cuff and the cuff of the glove. One to three turns then should be made with the tape around the wrists to secure the coverall sleeves to the glove cuffs. One turn is sufficient with wide tape (3-4 inch or 7.6-10 cm in width), whereas two or even three turns are required with narrow tape (1-2 inch or 2.5-5 cm in width).

Boots — Pull-on boots worn over stockinged feet are recommended in this risk category. The use of overshoes or overboots is not recommended. To permit thorough cleaning and decontamination, the boots should be of rubber or plastic waterproof material with shallow treads to permit thorough cleaning. Safety boots with flexible steel toes and midsoles, which provide extra protection from puncture wounds and events involving crushing, are especially recommended for wear in the field.

Respiratory and Eye Protection — For this risk category, the use of a protective hood with a face shield in conjunction with a battery powered air-purifying respirator (PAPR) may be required.

Desirable attributes for a hood with a face shield include wearer comfort, resistance to shifting during strenuous use, ease of cleaning and disinfection, a reasonable initial cost and shelf life, and commercial availability. Several hood configurations and styles are compatible with a PAPR. Use of a PAPR has many advantages, including:

- Comfort;
- Greater encapsulation from the outside environment than other respirators;
- Some limited body cooling effect during hot and/or humid weather; and
- Wearability by individuals with beards or mustaches.

The disadvantages of a PAPR include:

- Initial cost of purchase;
- The need for maintenance (e.g., battery recharging and filter replacement);
- Potential difficulty in disinfecting the blower units completely;
- Difficulty of user in communicating verbally with others; and
- Possible adverse perception by the farming public of a responder wearing a PAPR.