

# Secure Sheep and Wool Supply Plan: Wool Handling During a Foot and Mouth Disease (FMD) Outbreak



## Introduction

In the event of a foot and mouth disease (FMD) outbreak, it is possible that infected sheep could be shorn and their wool stored before the sheep are diagnosed with FMD<sup>1</sup>. Wool from an infected flock, and perhaps all wool from a Control Area will be considered to be contaminated with FMD virus. It must be assumed that, in some cases, wool from infected yet undetected flocks will enter the supply chain. Depending on environmental conditions, wool harvested from FMD infected animals can harbor the virus for weeks<sup>2</sup>. It is critical that any wool harvested during, or just before, a U.S. FMD outbreak be handled in a biosecure manner so it does not contribute to disease spread. This document provides guidance only. In an actual outbreak, decisions will be made by the Responsible Regulatory Officials based on the unique characteristics of the outbreak.

## FMD Virus Survivability in Wool

Wool is considered to be highly biodegradable, at least partially due to its structural protein, keratin, which readily breaks down – especially in warm, humid, and aerobic conditions<sup>3</sup>. However, clean, dry wool or wool kept in anaerobic conditions is extremely durable and has been unearthed thousands of years later<sup>3</sup>.

FMD virus (FMDV) has greater stability at lower temperatures, in the presence of organic matter, and when protected from sunlight<sup>4</sup>. Reported survival times of FMDV on wool was approximately two months at 4°C [39.2°F] (with significantly decreased survival at 18°C [64°F])<sup>4</sup>. FMDV can be inactivated in acid conditions (below 6.0 pH) or alkaline conditions (above 9.0 pH)<sup>4</sup>.

It is important to note that there are no USDA approved tests for detection of FMDV in wool<sup>5</sup>.

## Inactivating FMD Virus in Wool and Wool Handling Equipment

Wool and wool handling equipment can serve as a fomite to spread FMDV unless proper procedures are followed. The World Organization for Animal Health (WOAH) sets the international sanitary standards for trade in animal products to avoid transmitting pathogens between countries. Guidance is provided in the 2023 WOAH Terrestrial Animal Health Code, Article 8.8.32: *Procedures for the inactivation of FMDV in wool and hair*

“For the inactivation of FMDV present in wool and hair for industrial use, one of the following procedures should be used:

1. industrial washing, which consists of the immersion of the wool in a series of baths of water, soap and sodium hydroxide (soda) or potassium hydroxide (potash);
2. chemical depilation by means of slaked lime or sodium sulphide;
3. fumigation with formaldehyde in a hermetically sealed chamber for at least 24 hours;
4. industrial scouring which consists of the immersion of wool in a water-soluble detergent held at 60-70°C [140-158°F];
5. storage of wool at 4°C [39.2°F] for four months, 18°C [64.4°F] for four weeks, or 37°C [98.6°F] for eight days.”<sup>6</sup>

## Preparing Wool for Storage to Inactivate FMD Virus

Step five (5) in the list above may be most applicable to sheep operations in a Control Area who wish to request a movement permit to transport wool off-site for further processing. As previously stated, it is possible that FMD infected sheep could be shorn and their wool stored before the sheep are diagnosed.

Proper handling of the wool is necessary to ensure the FMDV is eliminated and the wool does not become re-contaminated during handling. The equipment used to harvest wool and bale it must also be treated as potentially contaminated. Cleaning and disinfecting equipment is important to minimize contamination, especially if the equipment is to be used on other premises. The following steps are recommended to prepare the wool for storage:

- Clean the wool and equipment to remove gross contamination.
- Bale large amounts of wool using impermeable (waterproof) plastic to package it.
  - Nylon packs or burlap bags are permeable and should be sealed on farm with a secondary plastic bale cover before storage or transfer.
  - If small amounts of wool are being handled, impermeable plastic trash bags may be used.
- Remove any gross contamination from the outside of the bale/bag.
- Clean the outside of the bale/bag.
- Disinfect the outside of bale/bag and equipment using a product registered by the U.S. Environmental Protection Agency and labeled for FMDV.
  - USDA guidance on FMD Virus Disinfectants is available at: [https://www.aphis.usda.gov/animal\\_health/emergency\\_management/downloads/fmd-virus-disinfectants.pdf](https://www.aphis.usda.gov/animal_health/emergency_management/downloads/fmd-virus-disinfectants.pdf)
- Bales/bags should be stored in a biosecure area that has not been potentially exposed to FMDV or has been properly cleaned and disinfected prior to use as storage.
- Bales/bags should be stored at a minimum of 4°C [39.2°F] for four months, 18°C [64.4°F] for four weeks, or 37°C [98.6°F] for eight days. FMDV is temperature sensitive so it is important that these temperatures are met for that length of time. Bale/bag temperatures should be systematically monitored and recorded (e.g., dated logbook) to ensure that bales/bags have reached the required temperature for the recommended time, paying special attention to the bale/bag core.
  - Temperature should be measured and documented during the coldest parts of the day to ensure that the required target temperature is being reached. It can always be “hotter”, but not colder (recall FMDV survives better in cold, damp conditions). Each bale/bag should be stored so that air can circulate around it.
  - Regulatory officials may require documentation of time and temperature monitoring as confirmation of the process prior to issuance of a movement permit.
- Once the appropriate temperature has been reached throughout each bale/bag for the required time, bales/bags may be eligible for movement under a permit.

## **Traceability of Wool Bales/Bags**

Traceability of wool bales/bags from infected farms or commingled wool from multiple flocks, one or more that may be infected, will be needed in an FMD outbreak. Every bale/bag within a shipment should be uniquely identified so that it can be traced back to the individual flock of origin. Establishing a bale/bag identification system prior to an outbreak is recommended because it is possible that FMD-infected sheep could be shorn and their wool stored before the sheep are diagnosed. Once the bale/bag is uniquely identified, the wool should remain in the original bale/bag, as delivered, and without additional sorting and re-baling. Accurate and complete record keeping is a critical part of traceability to manage an FMD outbreak. Corresponding records/ledgers should contain the bales/bag unique identifier, the premises identification number (PIN) from the flock of origin, the date of shearing, the dates of any movements of animals or wool prior to harvest, storage or resale, and the names and contact information of the grower.

## **Movement of Wool Recommendations**

Transport of wool into, within or out of a Control Area will require a movement permit. Wool that cannot be treated to standards established by the World Organisation for Animal Health (WOAH) should be destroyed on the premises. Refer to the Secure Sheep and Wool Supply (SSWS) Plan for Continuity of Business for movement permit guidance ([www.securesheepwool.org](http://www.securesheepwool.org)).

In addition to the SSWS Plan movement permit guidance:

- Wool originating from flocks within a Control Area should be treated to WOA standards for inactivation of FMDV before leaving the Control Area for further processing.
- Baled/bagged wool should be transported in a clean vehicle/trailer that has not been potentially exposed to FMDV or has been properly cleaned and disinfected prior to use for transport.

## Wool Disposal Options

### Burial

Burial is an inexpensive, biosecure, and commonly accepted means of carcass and certain byproduct disposal (both on- and off-site); however, there are a number of variables such as soil type, water tables, and environmental regulations<sup>7</sup> that must be addressed prior to use. In an FMD response, the Food and Agriculture Organization of the United Nations (FAO) and Australian Veterinary Emergency Plan recommend burial; citing the challenges and limitations associated with burning wool and unshorn carcasses<sup>8,9</sup>.

### Composting

Depending on situational factors, composting is one of the disposal methods suggested by USDA APHIS in the event of an FMD outbreak<sup>7</sup>. The FAO further suggests composting "...be done in secure area not accessible to susceptible animals<sup>8</sup>". This may limit the feasibility of implementing on-site composting for some operations. Composted wool has some positive benefits; it has been demonstrated that composting a combination of grass clippings, manure, and wool can create an acceptable grade fertilizer.<sup>10</sup> This may be feasible in farm flocks with small volumes of wool, but unlikely for operations with stacks of wool bales.

Furthermore, studies using swine and cattle carcasses have demonstrated that FMDV can be inactivated in compost, provided adequate internal temperatures are reached<sup>11,12</sup>. It seems plausible that wool infected with FMDV would behave similarly due to the FMD virus' susceptibility to high temperatures.

### Burning/Incineration

Wool is naturally flame retardant and has a high Limiting Oxygen Index (LOI) which is a measure of the oxygen level needed to sustain combustion<sup>13</sup>. Wool also has a very high ignition temperature (570-600°C [1058-1112°F]) and is self-extinguishing<sup>13</sup>. These factors represent significant challenges to burning wool or unshorn carcasses, as they tend to smolder for short periods of time only. Therefore, high-temperature incineration would likely be required. In some regions, there may be environmental restrictions limiting or prohibiting the use of burning/incineration of carcasses. Additionally, these methods may be deemed unacceptable by the public.

### Emerging Technologies

New and emerging technologies such as "dissolving" wool into keratin nano-materials using a "choline-chloride-urea solvent" which is then refined and freeze dried to form a protein powder that can be used in a variety of processes<sup>14,15</sup>. FMDV survivability during this process needs to be determined.

The hydrolysis of wool in superheated water can be carried out in different process conditions with different chemical agents. Boiling in alkali media represents the most common way to carry out a strong hydrolysis of keratin<sup>16</sup>. There is currently an initiative in the European Union with the goal of converting wool wastes into fertilizer using this process<sup>16</sup>. Given the high temperatures utilized in this process, it may present an alternative way to inactivate FMDV.

## Acknowledgments

This Secure Sheep and Wool Supply (SSWS) Plan: Wool Handling During a Foot and Mouth Disease Outbreak was developed by the Center for Food Security and Public Health (CFSPH), Iowa State University (ISU) College of Veterinary Medicine. This material was made possible in part by a grant from the American Sheep Industry Association (ASI).

## Additional Resources

The Secure Sheep and Wool Supply website has additional resources available at:  
[www.securesheepwool.org](http://www.securesheepwool.org)

## References

1. McColl K, Westbury H, Kitching, RP, Lewis VM. 1995. The persistence of foot-and-mouth disease virus on wool. *Australian veterinary journal*. 72:286-92. 10.1111/j.1751-0813.1995.tb03556.x.
2. USDA Foreign Animal Disease Preparedness and Response Plan. November 2018. Standard Operating Procedures: 15. Cleaning and Disinfection. [www.aphis.usda.gov/animal\\_health/emergency\\_management/downloads/sop/sop\\_cd.pdf](http://www.aphis.usda.gov/animal_health/emergency_management/downloads/sop/sop_cd.pdf). Accessed May 22, 2019.
3. Swan P. 2019. Wool is Biodegradable. International Wool Textile Organization (IWTO) Factsheets. [www.iwto.org/sites/default/files/files/iwto\\_resource/file/Wool%20is%20Biodegradable.pdf](http://www.iwto.org/sites/default/files/files/iwto_resource/file/Wool%20is%20Biodegradable.pdf). Accessed May 22, 2019.
4. Spickler, Anna Rovid. 2015. Foot and Mouth Disease. Accessed October 29, 2019 at: [www.cfsph.iastate.edu/Factsheets/pdfs/foot\\_and\\_mouth\\_disease.pdf](http://www.cfsph.iastate.edu/Factsheets/pdfs/foot_and_mouth_disease.pdf).
5. Christine Loiacono, personal communication, July, 2019.
6. [WOAH](http://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=1&htmfile=chapitre_fmd.htm) Terrestrial Animal Health Code, Infection with Foot and Mouth Disease Virus, 2015, Article 8.8.32, Procedures for the inactivation of FMDV in wool and hair. Accessed July 2023 at: [https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=1&htmfile=chapitre\\_fmd.htm](https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=1&htmfile=chapitre_fmd.htm)
7. USDA Foreign Animal Disease Preparedness and Response Plan. September 2014. Foot- and-Mouth Disease Response Plan: The Red Book [www.aphis.usda.gov/animal\\_health/emergency\\_management/downloads/fmd\\_responseplan.pdf](http://www.aphis.usda.gov/animal_health/emergency_management/downloads/fmd_responseplan.pdf). Accessed May 22, 2019.
8. Food and Agriculture Organization of the United Nations (FAO). 2001. Manual on Procedures for Disease Eradication by Stamping Out. Part 2: Disposal Procedures. [www.fao.org/3/Y0660E/Y0660E02.htm#TopOfPage](http://www.fao.org/3/Y0660E/Y0660E02.htm#TopOfPage). Accessed May 22, 2019.
9. Animal Health Australia. 2015. Operational manual: Disposal (Version 3.1). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3, National Biosecurity Committee, Canberra, ACT
10. Hustvedt G, Meier E, Waliczek T. 2016. The Feasibility of Large-Scale Composting of Waste Wool. 10.1007/978-981-10-0111-6\_4.
11. Guan J, Chan M, Grenier C, et al. Degradation of foot-and-mouth disease virus during composting of infected pig carcasses. *Can J Vet Res*. 2010;74(1):40–44.
12. Xu W, Reuter T, Inglis D, et al. Development of a composting system for emergency disposal of cattle carcasses and manure during an infectious disease outbreak. *J Environ Qual* 2009;38:437–450.
13. International Wool Textile Organization Wool and Flame Resistance. International Wool Textile Organization (IWTO) Factsheets. [www.iwto.org/sites/default/files/files/iwto\\_resource/file/Wool%20and%20Flame%20Resistance\\_IWTO%20Fact%20Sheet\\_20141124.pdf](http://www.iwto.org/sites/default/files/files/iwto_resource/file/Wool%20and%20Flame%20Resistance_IWTO%20Fact%20Sheet_20141124.pdf). Accessed May 22, 2019.
14. Flinders University. March 29, 2016. Recycling Waste Wool a Step Closer. <https://phys.org/news/2016-03-recycling-wool-closer.html>. Accessed May 22, 2019.
15. Moore K, et al. 2016. Wool deconstruction using a benign eutectic melt, *RSC Adv.* (2016). DOI: 10.1039/C5RA26516A
16. How the GreenWoolF Project Achieved To Convert Wool Wastes Into High Value Fertilizer. May 4, 2018. <https://www.euromontana.org/en/greenwoolf-project-achieved-convert-wool-wastes-high-value-fertilizer/>. Accessed May 22, 2019.