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Hazard Analysis and Risk-Based Preventive Controls for Food for Animals

Guidance for Industry

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U.S. Department of Health and Human Services
Food and Drug Administration
Center for Veterinary Medicine
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Contains Nonbinding Recommendations

Hazard Analysis and Risk-Based Preventive Controls for Food for Animals

Guidance for Industry

This guidance represents the current thinking of the Food and Drug Administration (FDA, Agency, or we) on this topic. It does not establish any rights for any person and is not binding on FDA or the public. You can use an alternative approach if it satisfies the requirements of the applicable statutes and regulations. To discuss an alternative approach, contact the FDA staff responsible for this guidance as listed on the title page.

INTRODUCTION

In Title 21 of the Code of Federal Regulations (21 CFR) part 507 (part 507), we have established our regulation entitled "Current Good Manufacturing Practice, Hazard Analysis, and Risk-Based Preventive Controls for Food for Animals." We published the final rule establishing part 507 in the *Federal Register* of September 17, 2015 (80 FR 56170). Part 507 establishes requirements for current good manufacturing practice for animal food (CGMPs), for hazard analysis and risk-based preventive controls for animal food (PCAF), and related requirements as shown in Table 1.

Table 1. Subparts Established in 21 CFR Part 507

SUBPART	TITLE
A	General Provisions
B	Current Good Manufacturing Practice
C	Hazard Analysis and Risk-Based Preventive Controls
D	Withdrawal of a Qualified Facility Exemption
E	Supply-Chain Program
F	Requirements Applying to Records That Must be Established and Maintained

Part 507, subparts A, C, D, E, and F contain the complete animal food preventive controls requirements (the PCAF requirements). This guidance document focuses on subpart C, the primary preventive controls requirements, and also discusses relevant recordkeeping requirements of subpart F. See our Guidance for Industry (GFI) #235 entitled "Current Good Manufacturing Practice Requirements for Food for Animals" that addresses the requirements in subpart B.[1] Although subpart E, the supply-chain program, is a type of preventive control, we address this preventive control in our Draft GFI #246 entitled "Hazard Analysis and Risk-Based Preventive Controls for Food for Animals: Supply-Chain Program."[2]

The PCAF requirements implement certain provisions of the FDA Food Safety Modernization Act (FSMA) established in section 418 of the Federal Food, Drug, and Cosmetic Act (FD&C

[1] https://www.fda.gov/media/97464/download

[2] https://www.fda.gov/media/113923/download

Act) (21 U.S.C. 350g). Part 507 includes several complete or partial exemptions from the PCAF requirements. For example, establishments not required to register as a food facility under section 415 of the FD&C Act (see 21 CFR 1.226) are exempt from part 507 (see 21 CFR 507.5(a)). See 21 CFR 507.5 for the full list of exemptions.

In part 507, "you" means the owner, operator, or agent in charge of a facility (see 21 CFR 507.3). However, for the purposes of this guidance document, where appropriate, "you" also may refer to the "preventive controls qualified individual" (PCQI) in addition to the owner, operator, or agent in charge of a facility.

Establishing risk-based preventive controls designed to protect your animal food and the consumer (humans purchasing the animal food and animals consuming the food) from biological, chemical (including radiological), and physical hazards, enables you to apply a proactive and systematic approach to your food safety program. Risk-based preventive controls will not give you a zero-risk system for manufacturing, processing, packing, and holding animal food; rather, risk-based preventive controls are designed to minimize the risk of known or reasonably foreseeable animal food hazards that may cause illness or injury to humans or animals if they are present in the animal food you produce.

This guidance document covers facilities that manufacture, process, pack, or hold food intended for all animal species including food-producing animals (e.g., cattle, swine, poultry, and aquaculture species), companion animals (e.g., dogs, cats, horses, and guinea pigs), laboratory animals, and animals maintained in zoological parks. "Animal food" means food for animals other than man and includes pet food, animal feed, and raw materials and ingredients (see 21 CFR 507.3). Therefore, the animal food discussed in this guidance includes raw materials and ingredients used to make animal food, partially manufactured animal food that may be further processed, and animal food ready for consumption.

This guidance document is intended to help you comply with the PCAF requirements in subparts C and F of part 507:

- a food safety plan
- hazard analysis
- preventive controls
- monitoring
- corrective actions and corrections
- verification (including validation)
- recall plan
- associated records

You need to apply preventive controls and the associated preventive control management components only if, after conducting a hazard analysis of each type of animal food manufactured, processed, packed, or held at your facility, you determine there are known or

reasonably foreseeable biological, chemical, or physical hazards that require a preventive control. We do not expect that all known or reasonably foreseeable hazards for an animal food require a preventive control in all facilities.

It is important for you to be aware of the known or reasonably foreseeable hazards that may be associated with your animal food, processes, and facility. When you understand the known or reasonably foreseeable hazards, it is easier to design and implement an effective food safety plan.

This guidance is not directed to persons who are exempt from the preventive controls requirements of part 507. However, such persons may find some of the principles and recommendations in this guidance helpful in manufacturing, processing, packing, and holding animal food to help ensure the safety of that animal food.

The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, unless specifically incorporated into a contract. This document is intended only to provide clarity to the public regarding existing requirements under the law. FDA guidance documents, including this guidance, should be viewed only as recommendations, unless specific regulatory or statutory requirements are cited. The use of the word *should* in Agency guidance means that something is suggested or recommended, but not required.

PURPOSE

The purpose of this guidance is to help you develop a food safety plan that complies with FDA's PCAF requirements. This guidance does not include every possible scenario for your food safety plan and the type of animal food you manufacture, process, pack, or hold, but is designed to assist you as you develop your food safety plan.

Specifically, this document provides guidance on how to:

- identify the biological, chemical (including radiological), and physical agents that are known or reasonably foreseeable hazards in manufacturing, processing, packing, and holding of animal food
- understand the components of a food safety plan and the importance of each component
- conduct a hazard analysis and develop a food safety plan for the animal food that you produce
- identify preventive controls for biological, chemical, and physical hazards requiring a preventive control and understand how to apply those preventive controls
- implement preventive control management components (i.e., monitoring, corrective actions and corrections, and verification (including validation))
- understand and implement the food safety plan as well as all recordkeeping requirements associated with the food safety plan

We recommend that you consider how this guidance relates to your operations and tailor your food safety plan to the specific circumstances for the animal food you produce at your facility. You have the flexibility to identify and implement preventive controls and associated preventive control management components from among all procedures, practices, and processes that provide assurances that the hazard requiring a preventive control is controlled (i.e., significantly minimized or prevented).

Terms we use that are defined in the regulation and that we define for purposes of this guidance are in quotations the first time they are introduced. For a list of definitions used in this guidance, see Appendix A. For a list of abbreviations and acronyms used in this guidance, see Appendix B.

CHAPTER 1 – THE FOOD SAFETY PLAN

1.1 Purpose of this Chapter

The guidance provided in this chapter is intended to help facilities that are subject to the preventive controls requiremApents of the Preventive Controls for Animal Food (PCAF) regulation understand what a food safety plan is. A facility subject to the preventive controls requirements must prepare, or have prepared, and implement a written food safety plan. See 21 CFR 507.31(a).

1.2 What is a Food Safety Plan?

A food safety plan is a written plan prepared by (or whose preparation is overseen by) a preventive controls qualified individual (21 CFR 507.31(a) and (b)), and it must include the elements listed in 21 CFR 507.31(c).

Below, we describe the written documents required in the food safety plan. See 21 CFR 507.31(c).

- Hazard analysis to identify and evaluate known or reasonably foreseeable hazards for each type of animal food at your animal food facility to determine whether there are hazards requiring a preventive control (see 21 CFR 507.33(a)(1)). Some facilities may not identify any known or reasonably foreseeable hazards associated with animal food at their facilities, or after evaluation may determine there are no known or reasonably foreseeable hazards requiring a preventive control. This hazard analysis must be written regardless of whether there are any hazards requiring a preventive control. See 21 CFR 507.33(a)(2).

- When the hazard analysis determines there are known or reasonably foreseeable hazards requiring a preventive control, the food safety plan also includes the following written documents:

    - Preventive controls (see 21 CFR 507.34), as appropriate to the facility and the animal food, that may include:
        - process controls
        - sanitation controls
        - supply-chain controls
        - recall plan
        - other preventive controls

    - Procedures for monitoring the implementation of the preventive controls, as appropriate to the nature of the preventive control and its role in the facility's animal food safety system. See 21 CFR 507.40(a).

    - Corrective action procedures, as appropriate to the nature of the hazard and the

nature of the preventive control. See 21 CFR 507.42(a)(1).

- Verification procedures, as appropriate to the facility, the animal food, and the nature of the preventive control and its role in the facility's animal food safety system. See 21 CFR 507.49(b).

- Recall plan. See 21 CFR 507.38(a)(1).

This written food safety plan is a record that you must maintain. See 21 CFR 507.31(d); and, 21 CFR part 507, subpart F, particularly 21 CFR 507.208. In addition, you must maintain records documenting implementation of the food safety plan. See 21 CFR 507.55 for a list of records that must be maintained to document implementation of the food safety plan.

1.3 Who Prepares the Food Safety Plan for a Facility?

A preventive controls qualified individual (PCQI) must prepare (or oversee the preparation of) the food safety plan. See 21 CFR 507.31(b).

A PCQI is a "qualified individual" who has successfully completed training in the development and application of risk-based preventive controls at least equivalent to that received under a standardized curriculum recognized as adequate by FDA, or is otherwise qualified through job experience to develop and apply a food safety system (see 21 CFR 507.3). A standardized curriculum recognized as adequate by FDA includes, for example, the animal food training course developed by the Food Safety Preventive Controls Alliance (FSPCA) (Ref. 1). The PCQI does not need to be an employee of the facility but should be familiar with the facility and the facility's operations.

1.4 Who Signs the Food Safety Plan for a Facility?

The food safety plan must be signed and dated by the owner, operator, or agent in charge of the facility when the food safety plan is first completed and whenever the plan is modified. See 21 CFR 507.206.

1.5 Is the Food Safety Plan the Same as a HACCP Plan?

Although a food safety plan and Hazard Analysis and Critical Control Point (HACCP) plan are similar, they are not identical. A HACCP plan is a written document based upon the principles of HACCP and which delineates the procedures to be followed. HACCP is a systematic approach to the identification, evaluation, and control of food safety hazards. HACCP systems, which are the result of the implementation of a HACCP plan, have been mandated by U.S. Federal regulations issued by the FDA for processing seafood and juice and by the United States Department of Agriculture Food Safety and Inspection Service (USDA/FSIS) for processing meat and poultry. No HACCP system has been mandated by FDA for any animal food. HACCP principles have been voluntarily adopted however by some segments of the animal food industry, such as some rendering facilities.

1.6 What if a Facility Already has a HACCP Plan?

If you have an existing HACCP plan, you should determine if your HACCP plan satisfies all the requirements for the food safety plan in the PCAF regulation. You can use existing programs, procedures, and records and supplement those with any additional information required. If you are using or planning to use a HACCP plan at your animal food facility, you may find helpful a complete discussion of the differences between a food safety plan and a HACCP plan in Chapter 1 of the draft GFI entitled "Hazard Analysis and Risk-Based Preventive Controls for Human Food."[3]

1.7 Is there a Required Format for a Food Safety Plan?

There is no standardized or required way to organize a food safety plan. The food safety plan may be in electronic or hardcopy format. The food safety plan is a record subject to the requirements in 21 CFR part 507, subpart F (see 21 CFR 507.31(d)).

You have flexibility in your approach to documenting your hazard analysis and in your approach to documenting preventive controls established for those hazards requiring a preventive control. The formats shown in this guidance are for illustrative purposes and may not be complete. You can use whatever format works best for your facility, provided that the food safety plan includes all the required information. The FSPCA training materials also provide example food safety plans for animal food that may be helpful (Ref. 1).

One approach for organizing the food safety plan to allow for signing and dating is to collect in a single location (e.g., a binder or folder) all the required documents with a cover page for the owner, operator, or agent in charge of the facility to sign and date. See 21 CFR 507.206. However, because the food safety plan also could be various documents kept in different locations within the facility, another approach is for the owner, operator, or agent in charge of the facility to sign and date a list of the required documents (e.g., as in a table of contents).

1.8 What Circumstances Require Review (Reanalysis) of My Food Safety Plan?

The food safety plan is a dynamic document that reflects your current hazard analysis, preventive controls, and other required elements (see 21 CFR 507.31). The food safety plan as a whole must be reanalyzed at least once every 3 years (21 CFR 507.50(a)). However, reanalysis of the plan as a whole or the applicable portion of the plan is required whenever a significant change in the activities conducted at your facility creates a reasonable potential for a new hazard or a significant increase in a previously identified hazard; you become aware of new information about potential hazards associated with the animal food; when appropriate after an unanticipated animal food safety problem that requires a corrective action; or, you find that a preventive control, combination of preventive controls, or the food safety plan as a whole is ineffective. See 21 CFR 507.50(b). You also must conduct a reanalysis of the food safety plan when FDA determines it is necessary to respond to new hazards and developments in scientific understanding. See 21 CFR 507.50(f). In the event that we make such a determination, we will

[3] https://www.fda.gov/media/100002/download

publicize such information in a format accessible to the public.

1.9 References for Chapter 1

1. Food Safety Preventive Controls Alliance. 2017. "Food Safety Preventive Controls Alliance Home Page". Accessed July 20, 2021. https://www.ifsh.iit.edu/fspca

CHAPTER 2 – CONDUCTING A HAZARD ANALYSIS

2.1 Purpose of this Chapter

The guidance provided in this chapter is intended to help you conduct a hazard analysis in accordance with the PCAF requirements. The hazard analysis must be written regardless of the outcome or results of the analysis, and must include two elements: (1) a hazard identification, and (2) a hazard evaluation to determine whether there are any hazards requiring a preventive control. See 21 CFR 507.33.

2.2 Overview of a Hazard Analysis

The term "hazard analysis" is not defined in part 507. See Box 2-1 for a definition of hazard analysis.

Box 2-1. Definition of Hazard Analysis

Hazard Analysis

The process of identifying and evaluating known or reasonably foreseeable hazards to determine whether there are any hazards requiring a preventive control.

This chapter guides you through the steps we recommend in conducting your hazard analysis. You are not required to use a certain format for conducting your hazard analysis. However, you may find it useful to use the Flow Chart in Appendix C and the Hazard Analysis and Preventive Controls Worksheet in Appendix D (also see Box 2-3 in this chapter). You may use other formats (including the use of a written narrative) as long as your hazard analysis contains the elements of hazard identification and hazard evaluation and a determination of whether any of the hazards require a preventive control.

Use your completed hazard analysis to determine whether any hazards require preventive controls. Your completed hazard analysis will be useful in determining the appropriate preventive control(s), if any, to use in your facility. The hazard identification and evaluation in your hazard analysis should help provide justification for your decisions.

You may group animal food products together for your hazard analysis if the animal food safety hazards and controls are essentially the same for all animal food products in the group, but you should clearly identify any product or process differences. Your written hazard analysis can be a resource for you if inspectors, investigators, auditors, or your customers ask you to explain how you determined that a preventive control is not required for a known or reasonably foreseeable hazard.

A proper analysis of biological, chemical (including radiological), and physical hazards associated with your animal food and your facility calls for good judgment, detailed knowledge of the properties of the raw materials and other ingredients, detailed knowledge of your

manufacturing, processing, packing, and holding processes, and access to relevant scientific expertise.

2.3 Recommended Activities in Conducting Your Hazard Analysis

We recommend that you conduct certain preliminary steps, and set up a Hazard Analysis Worksheet, as a useful framework for organizing and documenting your hazard analysis.

2.3.1 Conduct Preliminary Steps

Box 2-2. Recommended Preliminary Steps

1. Designate the preventive controls qualified individual (you may also assemble a food safety team).
2. Describe the animal food, its distribution, intended use, and the intended animal species, life stage, or production class.
3. Develop a process flow diagram (include the related process descriptions as needed) and conduct an on-site visit to verify the diagram is accurate.

You must have a preventive controls qualified individual (PCQI) prepare, or oversee the preparation of, your food safety plan. See 21 CFR 507.31(b). The food safety plan includes your written hazard analysis. See 21 CFR 507.31(c)(1). We recommend that a food safety team of individuals with expertise in the day-to-day operations of your facility help you conduct your hazard analysis under the oversight of a PCQI. Team individuals may include personnel from different areas, such as production, quality control, sanitation, or maintenance. Using individuals from different functions within the facility can help provide a complete understanding of your process and the things that could result in hazards in your animal food.

You can supplement the expertise of the food safety team with competent technical experts from other functional areas within the firm (where applicable), such as research and development, technical applications groups, and quality management, even though they may not be on-site at the facility. You also may find it helpful to bring in technical experts from outside of the firm such as experts from universities, cooperative extension services, trade associations, private consulting firms, raw materials and ingredients suppliers, or other sources.

The effectiveness of your food safety team is impacted by the quality and completeness of the information you provide to them about your facility and animal food to be assessed. Therefore, for this team to conduct the hazard analysis for the food safety plan, we recommend that you define and document the following details about your facility: (1) animal food type (including identification of the animal species, life stage or production class, and intended use) and its distribution, and (2) a process flow diagram (that includes the related process descriptions as needed).

A description of the animal food and how the animal food will be distributed and used helps the

PCQI understand elements of, or handling of, the animal food that may impact animal food safety such as proper storage conditions and any required labeling information (e.g., "Do not feed to cattle or other ruminants"). To help your PCQI, the description could include the: (1) full name of the finished animal food, description of the general formulas, or description of the type of animal food, (2) species and life stage or production class, (3) the packaging type and material, and (4) storage and distribution details. Finished animal food could be ready for consumption or it could be an ingredient or mixture of ingredients that will be further processed, mixed, or blended before the food is suitable for feeding to animals.

Understanding how the animal food will be fed to the animal (e.g., fed in fields, troughs, or in a pet owner's home) and knowing the intended animal being fed (e.g., dairy cow or dog) helps to determine which hazards require a preventive control. For example, a facility manufacturing pet food should consider that the animal food will be directly handled by humans and fed in the home as opposed to livestock animal food that is added to a trough usually without direct contact by humans. Therefore, handling of pet food by humans in the home is an important factor to consider when conducting your hazard analysis (see 21 CFR 507.33(d)(8)).

The purpose of a process flow diagram is to provide a clear, simple description of each of the steps involved in the processing of your animal food and its associated ingredients as they flow through your facility from receipt to distribution. The process flow diagram should cover all steps in the process that the facility performs, including receiving and storage steps for raw materials or other ingredients, preparation, processing, packaging, storage, and distribution of the product. Additionally, the process flow diagram should identify the equipment used. An accurate process flow diagram serves as a useful organization format by identifying each of the process steps that you need to assess for the hazard analysis. You should verify the process flow diagram onsite in order to ensure no steps have been overlooked.

The purpose of including related process descriptions is to help explain what happens at each of the process steps within your facility. For example, a process description that includes where and when micro ingredients (e.g., vitamins, minerals, drugs, and other materials normally required in small amounts and measured in milligrams, micrograms, or parts per million) are added to an animal food or whether a micro ingredient is added manually can help you identify the known or reasonably foreseeable hazards associated with your facility or your animal food.

2.3.2 Hazard Analysis Worksheet

Once your PCQI (and food safety team if applicable) gathers the information you will use to conduct your hazard analysis, we recommend that you set up a method to organize your hazard analysis. The Hazard Analysis Worksheet (HA worksheet) we provide in this guidance can be a useful tool to organize your written hazard analysis, although, as stated in section 2.2, you may use any method that results in a written hazard analysis. In this section, we discuss how to set up the HA worksheet. See Box 2-3 for an example of an HA worksheet. For an alternative form, see the FSPCA model food safety plan (Ref. 1).

The HA worksheet is organized by column. The information needed for the first four columns is explained in this chapter and Chapter 3. Chapter 4 describes more thoroughly the information

needed for columns five and six.

Column 1 – Ingredient and Processing Step: List the ingredients used in your process as a way of identifying hazards associated with an ingredient (you may group similar ingredients such as grains); and the processing steps. A process flow diagram and detailed process description (see Box 2-2) can help you identify the processing steps included in your hazard analysis.

Column 2 – Known or Reasonably Foreseeable Hazard: List the results of your identification of the known or reasonably foreseeable hazards from your hazard analysis. Include biological, chemical, or physical hazards that could be introduced or increased from ingredients, your process, or the environment. See section 2.4.1.

Column 3 – Does the Known or Reasonably Foreseeable Hazard Require a Preventive Control: For each known or reasonably foreseeable hazard identified in column 2, record the conclusions of your hazard analysis – i.e., the determinations you make whether each known or reasonably foreseeable hazard requires a preventive control ("Yes" or "No"). See section 2.4.2.

Column 4 – Explanation/Justification: You should justify, or explain, your "Yes" or "No" conclusion for column 3 based on your evaluation of the hazard. Record the key factors or a summary of the evaluation that led to the determination for each hazard of whether a preventive control is required. Explaining your reasons for a "No" conclusion can be just as important as explaining your reasons for a "Yes" conclusion. See section 2.5.

Column 5 – Preventive Control(s) Applied: Identify the preventive control(s) you will apply to significantly minimize or prevent the hazard requiring a preventive control (indicated by "Yes" in column 3). You might list, for example, the type of preventive control (e.g., process, sanitation, or supply-chain-applied controls), or list the specific preventive control you select (e.g., irradiation, time and temperature, or a_w). See section 2.6, and Chapter 4.

If the identified hazard does not require a preventive control, (indicated by "No" in column 3), you can leave the corresponding cell blank or put in "N/A" for not applicable.

Column 6 – Is the Preventive Control Applied at this Step: The HA worksheet allows you to break your production process into multiple steps (such as receiving or processing), and you may apply your preventive control at a step in the process other than the step where you list the hazard. Specify whether the preventive control will be applied at the specific processing step (i.e., "Yes" or "No"). See section 2.7.

Box 2-3. Example Hazard Analysis Worksheet (see Appendix D)

(Column 1) Ingredient and Processing Step	(Column 2) Known or Reasonably Foreseeable Hazard	(Column 3) Does the Known or Reasonably Foreseeable Hazard Require a Preventive Control? "Yes" or "No"	(Column 4) Explanation/ Justification	(Column 5) Preventive Control(s) Applied	(Column 6) Is the Preventive Control Applied at this Step? "Yes" or "No"

2.4 Conducting a Hazard Analysis

2.4.1 Identify Known or Reasonably Foreseeable Hazards (Hazard Identification)

You must identify known or reasonably foreseeable hazards for each type of animal food manufactured, processed, packed or held at your facility (see 21 CFR 507.33(a)). The hazard identification must consider known or reasonably foreseeable hazards that include biological, chemical (including radiological), and physical hazards that may be present in the animal food for any of the following reasons: (1) the hazard occurs naturally, (2) the hazard may be unintentionally introduced, or (3) the hazard may be intentionally introduced for purposes of economic gain. See 21 CFR 507.33(b)(1) and (2).

We recommend that you start with an exercise such as a brainstorming session to identify hazards that are known to be, or have the potential to be, associated with your facility or animal food (the known or reasonably foreseeable hazards). A brainstorming session can help you generate a list of biological, chemical, and physical hazards. Things you could consider as you work through this procedure include:

- Information about the animal food type (including identification of the animal species, life stage or production class, and intended use) and its distribution.

- Raw materials and other ingredients used in the animal food. Hazards, such as pathogens known to be associated with specific types of animal food, may be introduced during product manufacturing. For example, various ingredients may contain pathogenic bacteria that need to be significantly minimized or prevented to produce a safe pet food.

- In-plant experience regarding what hazards may be associated with the finished animal food. This may include product testing results, consumer complaints, or knowledge of facility personnel about the condition, function, and design of the facility relevant to contamination.

- Activities conducted at each step in the manufacturing process. Some activities may unintentionally introduce hazards into the animal food (e.g., chopping with a metal blade may introduce metal fragments; conveying with a broken plastic leg cup may introduce

plastic fragments; or, an improper bin cleanout may result in nutrient toxicities or deficiencies in animal food).

- Equipment used to make the animal food. Some types of equipment are more difficult to clean than others or are more prone to damage, which may increase the risk of hazards (e.g., biological or physical) being introduced into the animal food.

- Sanitation practices. You should consider the sanitary conditions within the facility (e.g., cleanliness of equipment and processing environment) and employee hygiene.

- External information. Sources may include scientific papers, epidemiological studies (e.g., data from previous foodborne illness incidents associated with ingredients or processes relevant to an animal food), information from applicable government or industry food safety documents, and if available, historical data for similar animal food.

After reviewing all relevant information, the PCQI (with the food safety team if applicable) can develop a list of known or reasonably foreseeable hazards that may be introduced or increased (e.g., due to pathogen growth) at each step in your manufacturing process. A process flow diagram can be a useful tool to identify where in your process a known or foreseeable hazard could be introduced.

Chapter 3 of this guidance can be used to help you identify known or reasonably foreseeable hazards for your animal food. Chapter 3 provides a review of biological, chemical, and physical hazards. The hazards described in Chapter 3 do not represent all possible hazards, nor are all of these hazards found in all facilities or types of animal food. You are responsible for identifying known or reasonably foreseeable hazards for each type of animal food manufactured, processed, packed, or held at your facility, even if they are not listed in Chapter 3.

2.4.2 Evaluate Known or Reasonably Foreseeable Hazards (Hazard Evaluation)

Each known or reasonably foreseeable animal food hazard must be evaluated to assess the following (see 21 CFR 507.33(c)(1)):

- Severity of the illness or injury to humans or animals if the hazard were to occur.
- The probability of occurrence of the hazard in the absence of a preventive control.

Your written hazard analysis also must:

- Include an evaluation of environmental pathogens whenever an animal food is exposed to the environment prior to packaging and the packaged animal food does not receive a treatment or otherwise include a control measure (such as a formulation lethal to the pathogen) that would significantly minimize the pathogen (see 21 CFR 507.33(c)(2)).

- Consider the effect of certain factors on the safety of the finished animal food for the intended animal such as design of the facility and storage and distribution (see 21 CFR 507.33(d)).

Assessing severity of the illness or injury

To assess the severity of the illness or injury if the hazard were to occur, you should consider certain factors, including:

- Susceptibility of the animal to the illness or injury (e.g., dogs are more susceptible to aflatoxin than most other species).
- Susceptibility of humans to the illness or injury (e.g., infants, children, and immunocompromised individuals may be more susceptible to certain foodborne illnesses from handling pathogen contaminated pet food, or through consuming products derived from animals that had consumed contaminated food).
- The potential magnitude and duration of the illness or injury (e.g., how long an animal may be sick, whether the illness requires veterinary care and hospitalization, and production loss such as a decline in milk or egg production).
- The possible impact of secondary problems (e.g., chronic sequelae such as kidney damage or neurological disease).

If your facility does not have the expertise to assess the severity of an illness or injury that could result from a known or reasonably foreseeable hazard, you (and your PCQI) could consult with outside experts.

Assessing probability the hazard will occur

The probability (i.e., likelihood) of occurrence of a particular hazard in the absence of a preventive control can be influenced by:

- frequency of association of the hazard with the animal food or facility
- effectiveness of facility programs such as current good manufacturing practices (CGMPs) or other prerequisite programs
- method of manufacture in the facility
- conditions during transportation
- expected storage conditions during holding at the facility or after distribution
- intended use of the animal food

Knowing your animal food, ingredients, processes, packaging, transportation, distribution, and the use of the animal food is helpful in estimating the likely occurrence of known or reasonably foreseeable hazards. Hazards likely to occur in one operation or facility may not be likely to occur in another operation or facility producing the same or similar animal food because different equipment and processes may be used, the ingredients and their source may be

different, or different transportation services are used. For example, one facility manufactures with only local grains while another facility receives most of its grains from out of state where growing and harvesting conditions may differ. You should consider each facility location individually when estimating the likelihood of occurrence of an animal food safety hazard.

You also could consider your facility's implementation of prerequisite programs when evaluating the probability that a hazard will occur in the absence of a preventive control. Proper implementation of an adequate prerequisite program may decrease the probability the hazard will occur. This probability may decrease to such a level that you determine the hazard does not require a preventive control. If you rely on a prerequisite program in your evaluation of the probability of occurrence of a hazard, adequate information about the prerequisite program must be included in your hazard analysis as part of your evaluation (see 21 CFR 507.33(c)). Adequate information in your hazard analysis could include a copy or sufficient description of standard operating procedures (SOPs) for your prerequisite program to document the procedures your facility follows to reduce the probability a hazard will occur in the absence of a preventive control. During an inspection, FDA could determine that your prerequisite program or its implementation does not adequately reduce the probability of the hazard occurrence and that a preventive control (and associated preventive control management components) is necessary for the hazard.

Examples of prerequisite programs include CGMPs (21 CFR part 507, subpart B), compliance with requirements on the use of animal proteins in ruminant feed (21 CFR 589.2000 and 589.2001, the bovine spongiform encephalopathy (BSE) regulations), and a facility's standard operating procedures. For example, the BSE agent is a hazard that may cause severe illness in cattle and humans. A facility that handles protein derived from mammalian tissues or cattle material prohibited in animal food may consider compliance with FDA's BSE regulations as a prerequisite program. If the facility is properly implementing the requirements in the regulation, the facility may conclude that their prerequisite program adequately reduces the probability that the BSE agent will occur in the absence of a preventive control. This conclusion may lead the facility to determine that the hazard does not require a preventive control. We recommend that you provide an explanation for your decision, based on your evaluation, in the explanation/justification section (column 4) of your hazard analysis worksheet.

When estimating likelihood of occurrence, you should consider information from available sources, which may include the following:

- data from foodborne illness incidents
- data from recalls
- data from the Reportable Food Registry[4]
- information in the scientific literature
- facility's historical information

[4] https://www.fda.gov/food/compliance-enforcement-food/reportable-food-registry-industry

Data from foodborne illness incidents

You should consider foodborne illness incidents associated with the same or similar animal food types. The Centers for Disease Control and Prevention (CDC) and FDA provide some information on outbreaks in humans from exposure to animal food. See Box 2-4 for sources. See references in section 2.8 for links to access this information.

Box 2-4. Sources of Data about Outbreaks

Food and Drug Administration (FDA)

- Outbreaks of Foodborne Illness – reports for FDA regulated foods (Ref. 2)

Centers for Disease Control and Prevention (CDC)

- Foodborne Outbreak Online Database – searchable by pathogen for U.S. outbreaks related to animal food (Ref. 3)

Data from recalls

Recalls provide useful information for understanding the types of hazards found in animal food. We classify recalls as specified in 21 CFR 7.3(m).

Recall classification means the numerical designation (i.e., I, II, or III) FDA assigns to a particular product recall indicating the relative degree of health hazard presented by the recalled product.

- Class I is a situation in which there is a reasonable probability that the use of, or exposure to, a violative product will cause serious adverse health consequences or death (21 CFR 7.3(m)(1))

- Class II is a situation in which use of, or exposure to, a violative product may cause temporary or medically reversible adverse health consequences or where the probability of serious health consequences is remote (21 CFR 7.3(m)(2))

- Class III is a situation in which use of, or exposure to, a violative product is not likely to cause adverse health consequences (21 CFR 7.3(m)(3))

Federal and State Web sites post information on food recalls. See Box 2-5. Also see references in section 2.8 for links to access this information.

Box 2-5. Sources of Data about Recalls

- **FDA Recalls, Market Withdrawals, and Safety Alerts** (Ref. 4)
- **U.S. Department of Agriculture, Food Safety and Inspection Service Recall Archive** (Ref. 5)

Data from the Reportable Food Registry

The Reportable Food Registry (RFR) is an electronic portal for industry to report when there is reasonable probability that the use of or exposure to an article of food will cause serious adverse health consequences or death. The RFR helps FDA better protect public health by tracking patterns and targeting inspections. The responsible party at a registered food facility is required to report when there is a reasonable probability that the use of, or exposure to, an article of food will cause serious adverse health consequences or death to humans or animals. (See section 417 of the FD&C Act). We release an annual RFR report that provides a synopsis of a one-year reporting period (Ref. 6). When conducting your hazard analysis, the RFR reports can be helpful to understand the types of hazards that have previously been associated with animal food and to identify new and emerging animal food hazards.

Information in the scientific literature

Peer-reviewed scientific journals and other sources of technical literature (e.g., Codex Alimentarius Commission (Codex), the Food and Agriculture Organization, and the World Health Organization) provide considerable information on foodborne hazards, their occurrence, potential for growth in food, and their control (Refs. 7, 8 and 9). Codex maintains internationally recognized codes of practice that are based on scientific literature and are available in several languages. USDA provides a microbial modeling program that is available online and can be used to evaluate potential growth of pathogens under a variety of conditions (Ref. 10). Keep in mind that modeling programs may not reflect exactly what will occur in a particular animal food, but they can provide an estimate of relative risk of different scenarios.

We provide guidance documents about animal food safety, which represent FDA's current thinking on a topic. Trade associations also provide animal food safety recommendations for specific types of animal foods and industry needs. Another useful resource is the Google Scholar search engine.

Facility's historical information

You may already have considerable information on your products from various laboratory tests on finished animal food, ingredients, in-process materials, or environmental monitoring. In addition, you may have experienced a contamination problem in the past that suggests a hazard is known or reasonably foreseeable, or received consumer complaints about certain hazards, such as physical hazards. You should consider your facility's historical data when conducting your hazard evaluation.

2.4.3 Assessing the Combination of Severity and Probability

You can separately assess: (1) the severity of illness and injury if the hazard were to occur, and (2) the probability of the hazard's occurrence in the absence of a preventive control. However, you also can consider the combination of severity and probability when evaluating the known or reasonably foreseeable hazard to determine if the hazard requires a preventive control.

For example, an illness or injury may have a moderate severity (e.g., may require medical or veterinary intervention in most cases), but the probability that the hazard will occur in the absence of a preventive control is low (e.g., rarely occurs in your type of animal food). If you look at the severity of the illness/injury and the probability that the hazard that causes the illness/injury will occur in the absence of a preventive control independently, the determination of whether the hazard requires a preventive control may be difficult in situations when the severity is moderate but probability is low (or the reverse). Looking at the severity and probability in combination may be helpful in making the determination of whether the hazard requires a preventive control.

Evaluating the combination of severity and probability can be done in different ways. See the FSPCA animal food curriculum for an example of a system to evaluate severity and probability in combination (Ref. 1). If you evaluate the combination of severity and probability for the hazard using a specific system, we will consider that system part of your hazard analysis, which must be written (see 21 CFR 507.33(a)(2)).

2.4.4 Evaluating Environmental Pathogens When Animal Food is Exposed to the Environment

If the animal food you make is exposed to the environment in your facility before packaging, the animal food could be contaminated with environmental pathogens such as *Listeria monocytogenes* (*L. monocytogenes*) or *Salmonella*. You must then include an evaluation of environmental pathogens in your hazard evaluation if the animal food you make is exposed to the environment before packaging and does not receive a treatment or include a control measure that would significantly minimize the pathogen. See 21 CFR 507.33(c)(2).

2.4.5 Evaluation of Other Factors

When evaluating hazards, you must consider the effect of the following on the safety of the finished animal food for the intended animal (21 CFR 507.33(d)):

- The formulation of the animal food: The addition of certain ingredients such as acids and preservatives may be critical to the safety of the finished animal food, because they may inhibit growth of, or even kill, microorganisms of public (human and animal) health significance. This could impact the evaluation at steps during production and storage with respect to pathogen growth. A multicomponent animal food may have individual ingredients that do not support growth of undesirable microorganisms (e.g., because of pH or a_w), but when the ingredients are put together, the resulting intrinsic factors (e.g.,

pH and a_w) may favor the growth of undesirable microorganisms.

- The condition, function, and design of the facility and equipment: The condition, function, or design of a facility or its equipment could potentially result in hazards in finished animal food. For example, some equipment in a pet food facility (e.g., some extruders, dryers, and conveying equipment) may be difficult to clean (e.g., because of close fitting components or hollow parts) and thus provide more opportunities for pathogens to become established in a niche environment than equipment designed to address the problem of pathogen harborage in niche environments. Equipment designed with metal-to-metal contact (e.g., metal scrapers or hammer blades) may generate metal fragments (a physical hazard). A facility that manufactures, processes, packs, or holds animal food such as raw pet food may have cold, moist conditions that are conducive to the development of a niche where the pathogen *L. monocytogenes* can become established and contaminate animal food-contact surfaces and finished animal food.

- Raw materials and other ingredients: A finished animal food can become contaminated through the use of contaminated animal food ingredients. For example, corn can be contaminated with aflatoxin, a chemical hazard. Machinery-harvested ingredients may be contaminated with physical hazards because the machinery may pick up foreign material from the field or not adequately separate foreign material from the harvested crop.

- Transportation practices: The safety of a finished animal food may be affected by transportation practices for incoming raw materials and ingredients or for the outgoing finished animal food. For example, you could consider whether an ingredient may require time and temperature control to ensure safety, or a bulk ingredient may need protective covering to prevent physical hazards. You also should be aware of applicable requirements of the Sanitary Transportation of Human and Animal Food regulation in 21 CFR part 1, subpart O, which helps ensure that motor vehicle and rail vehicle transportation practices do not create food safety risks.

- Manufacturing/processing procedures: Hazards may arise from manufacturing/processing procedures such as mixing of micronutrients that could result in nutrient deficiencies or toxicities (e.g., excessive vitamin D in dog food, excessive copper in food for sheep, or inadequate thiamine in thermally processed cat food) in the finished animal food. Some animal food facilities may use automated systems for ingredient addition. When not operating correctly, these systems can add ingredients to the wrong batch, fail to add ingredients, or add the incorrect amount of an ingredient to a batch resulting in a nutrient deficiency or toxicity hazard or drug hazard. In the production of nonmedicated animal food in a medicated feed facility, the manufacturing/processing procedures may result in unsafe contamination from drug carryover to the nonmedicated animal food due to inadequate cleanout procedures or improper sequencing of different animal food (e.g., the use of monensin, which is safe for use for cattle but toxic to horses, could result in unsafe contamination from drug carryover).

- Packaging activities and labeling activities: The packaging of an animal food can vary

(e.g., reusable totes, single use poly bags, cans, or pouches). Improper packaging could introduce a hazard into the animal food. You should ensure the finished animal food will be labeled appropriately. Some animal food may need labeling information to ensure safe use of the finished animal food. For example, the manufacturer of a copper supplement might include the use levels for animal food for different species or a labeling statement specifying the maximum safe level of copper in an animal food intended for sheep.

- Storage and distribution: Some finished animal food is stored and distributed under certain conditions to maintain safety (e.g., refrigerated pet food). There may be an increased probability that a hazard will occur in the absence of a preventive control for such animal food.

- Intended or reasonably foreseeable use: Animal food is often manufactured to meet the specific nutrient requirements of the intended species. For example, a diet manufactured for beef cattle may contain higher levels of copper compared to a diet intended for sheep due to the differences in nutrient requirements. The intended or reasonably foreseeable use is that the diet will be fed to beef cattle and not to sheep because a high copper diet would be toxic to sheep. Some animal food, e.g., pet food, is expected to be fed in the home, where humans might be exposed to biological hazards from handling the pet food.

- Sanitation, including employee hygiene: Sanitation measures and practices can impact the likelihood of a hazard being introduced into animal food. For example, the frequency with which a production line is shut down for a complete cleaning can impact the potential for animal food residues to transfer pathogens from equipment to the animal food (e.g., pathogens present on raw meat that could carry over into the next production cycle on a line). Practices directed at worker health and hygiene such as handwashing can reduce the potential for transfer of pathogens such as *Salmonella.*

- Any other relevant factors, such as the temporal (e.g., weather-related) nature of some hazards (e.g., levels of some natural toxins): Hazards such as aflatoxin are subject to a weather-dependent effect in that aflatoxin levels in some raw agricultural commodities are more of a problem in some years than in others.

2.5 Use of Your Written Evaluation as Explanation/Justification Whether a Hazard Requires a Preventive Control

You must include in your food safety plan your written hazard evaluation, which is part of your written hazard analysis (see 21 CFR 507.31(c)(1)). Your evaluation should provide justification for determining that a known or reasonably foreseeable hazard does or does not require a preventive control.

If you use the HA worksheet shown in Box 2-3 and Appendix D, your determination about whether a hazard requires a preventive control is shown by a "Yes" or "No" answer in column 3. You base this determination on your written evaluation of the severity of the illness or injury if the hazard occurs and the probability the hazard will occur in the absence of a preventive control, as well as any other relevant evaluation factors you consider (see 21 CFR 507.33(c) and (d)).

In column 4 of the HA worksheet, you would explain or justify your column 3 "Yes" or "No" answer. Depending on the length of your written hazard evaluation, the justification may be the entirety of your evaluation, could be a shortened summary of your evaluation, or could be a reference to a separate document in your food safety plan.

For example, your facility identifies metal fragments as a known or reasonably foreseeable hazard. You have implemented a system of prerequisite programs with SOPs for the use of screens and magnets that include daily observation and cleaning as needed of the screens and magnets. You evaluate this hazard by assessing the severity of the injury a metal fragment could cause. Based on your written evaluation, you determine that the metal hazard would result in minimal or no illness or injury to the animals consuming your animal food. You also determine there would be no illness or injury to humans consuming products derived from food-producing animals that ate your animal food contaminated with metal fragments or through handling the animal food. You then assess the probability the metal hazard will occur in the absence of a preventive control. Based on your written evaluation, you determine that the probability of occurrence of the metal hazard in the absence of a preventive control is low, in part because of the implementation of your system of prerequisite programs.

If you use the HA worksheet in Box 2-3 and Appendix D, your column 4 justification could be a short statement referencing your SOPs for the use of screens and magnets. Because you rely in part on your system of prerequisite programs in your evaluation of a hazard, adequate information about your system (e.g., a copy or an adequate description of the SOP) must be included in your hazard analysis.

If your HA worksheet is the only place that you document your written evaluation, you must include your HA worksheet in your food safety plan and your worksheet must include your assessment of the severity of illness or injury and the probability of occurrence of the hazard in the absence of a preventive control (see 21 CFR 507.33(c)(1)). Therefore, you may want to include additional columns to the HA worksheet to record your severity and probability assessments. See the FSPCA curriculum for animal food for an alternate example of a hazard analysis worksheet (Ref. 1).

2.6 Identifying Preventive Controls

Preventive Controls

Those risk-based, reasonably appropriate procedures, practices, and processes that a person knowledgeable about the safe manufacturing, processing, packing, or holding of animal food would employ to significantly minimize or prevent the hazards identified under the hazard analysis that are consistent with the current scientific understanding of safe food manufacturing, processing, packing, or holding at the time of the analysis. (21 CFR 507.3)

For each hazard that you identified in column 2 as known or reasonably foreseeable and then indicated in column 3 as requiring a preventive control, you must identify and implement at least

one preventive control to significantly minimize or prevent the hazard (see 21 CFR 507.34(a)(1)). See Chapter 4 – Preventive Controls for a detailed description of preventive controls.

If a preventive control can be applied at a point or step in the animal food production process and is essential at that point to prevent or eliminate the hazard requiring a preventive control, or reduce it to an acceptable level, you should classify the point or step as a critical control point (CCP). There are several preventive control approaches, which may or may not include CCPs, that you can consider depending on the known or reasonably foreseeable hazard and where in the process flow you determine the control measure should be applied. These include:

- process controls (21 CFR 507.34(c)(1))
- sanitation controls (21 CFR 507.34(c)(2))
- supply-chain controls (21 CFR 507.34(c)(3))
- other preventive controls (21 CFR 507.34(c)(5))

Process controls are applied at specific processing steps where parameters such as time and temperature must be controlled to significantly minimize or prevent a hazard. Sanitation controls may be important to prevent contamination with microbial pathogens. Supply-chain controls involve use of the supply-chain program for a hazard that the receiving facility has identified in raw materials or ingredients and that will be controlled by the supplier (see 21 CFR part 507, subpart E). Other preventive controls, that do not meet the definition of process controls, sanitation controls, or supply-chain controls, include any other procedures, practices, and processes necessary to significantly minimize or prevent a hazard. Examples of other controls include hygiene training and other current good manufacturing practices.

For every hazard you determine requires a preventive control, you must identify and implement at least one preventive control. See 21 CFR 507.34(a)(1). Importantly, remember that more than one hazard may be addressed by a preventive control. For example, several vegetative pathogens, such as *Salmonella*, *L. monocytogene*s, and pathogenic *E. coli*, are killed by sufficient heating. If you use the HA worksheet in Box 2-3, record the preventive controls that you choose in column 5 of the HA worksheet for each "Yes" answer in column 3. If the hazard does not require a preventive control, you would not complete columns 5 and 6.

2.7 Is the Preventive Control Applied at this Step?

When evaluating the known or reasonably foreseeable hazards, you should identify the step or steps in your production of animal food where the hazard may occur (such as receiving, processing, packaging, or storage). Once you determine that a hazard requires a preventive control, you then identify a preventive control that will significantly minimize or prevent the hazard and determine where in your production process to apply the preventive control. Determining that a hazard occurs at a particular processing step does not mean that the hazard must be controlled at that processing step.

For example, you may identify *Salmonella* as a hazard in raw meat ingredients at the receiving

step of your production process. You determine that the hazard does not need to be controlled at receiving because the raw meat is going to undergo a preventive control during processing that will significantly minimize the *Salmonella* hazard. If you use the HA worksheet in Box 2-3, record in column 6 that the hazard would not be controlled at the receiving step and would instead be controlled during the processing step (i.e., "Yes" or "No").

2.8 References for Chapter 2

1. Food Safety Preventive Controls Alliance. 2016. "Preventive Controls for Animal Food Participant Manual". First Edition v.1.0.

2. Food and Drug Administration. 2017. "Outbreaks of Foodborne Illness". Accessed August 09, 2021. https://www.fda.gov/food/recalls-outbreaks-emergencies/outbreaks-foodborne-illness

3. Centers for Disease Control and Prevention. 2021. "List of Selected Multistate Foodborne Outbreak Investigations". Accessed August 09, 2021. https://www.cdc.gov/foodsafety/outbreaks/multistate-outbreaks/outbreaks-list.html

4. Food and Drug Administration. 2017. "Recalls, Market Withdrawals, & Safety Alerts" (FDA email sign-up webpage). Accessed April 22, 2022. https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts

5. United States Department of Agriculture Food Safety and Inspection Service. 2017. "Recall Case Archive". Accessed August 09, 2021. https://www.fsis.usda.gov/wps/portal/fsis/topics/recalls-and-public-health-alerts/recall-case-archive

6. Food and Drug Administration. 2016. "Reportable Food Registry Annual Report". Accessed April 22, 2022. https://www.fda.gov/food/reportable-food-registry-industry/reportable-food-registry-annual-report

7. Codex Alimentarius Commission. 2012. "Prevention and Reduction of Food and Feed Contamination". Accessed August 09, 2021. http://www.fao.org/feed-safety/resources/resources-details/en/c/1051489/

8. Food and Agriculture Organization of the United Nations. 2017. "Food Safety & Quality at FAO" homepage. Accessed August 09, 2021. http://www.fao.org/food/food-safety-quality/home-page/en/

9. World Health Organization. 2017. "Food safety". Accessed August 09, 2021. http://www.who.int/foodsafety/en/

10. United States Department of Agriculture. 2016. "USDA Pathogen Modeling Program". Accessed August 09, 2021. https://www.ars.usda.gov/northeast-area/wyndmoor-pa/eastern-regional-research-center/residue-chemistry-and-predictive-microbiology-

research/docs/pathogen-modeling-program/pathogen-modeling-program-models/pmp/

CHAPTER 3 – HAZARDS ASSOCIATED WITH THE MANUFACTURING, PROCESSING, PACKING, AND HOLDING OF ANIMAL FOOD

3.1 Purpose of this Chapter

The guidance provided in this chapter is intended to help you consider the biological, chemical, and physical hazards that may be known or reasonably foreseeable hazards in animal food facilities and that may be applicable to your facility and animal food. It is important for you to understand the hazards that may be associated with your products, using the raw materials and other ingredients, processes, and equipment specific for those products, as well as the environment of your specific facility. This chapter does not provide an exhaustive compilation of hazards or details about each hazard. Where possible, we cite scientific literature, regulations, or guidance that may provide useful detailed discussion or analysis of hazards. The hazards described in Chapter 3 are not found in all facilities or types of animal food.

Although this chapter sometimes describes the types of preventive controls that may be appropriate for you to implement to control specific hazards, see Chapter 4 – Preventive Controls of this guidance for more detailed discussion of preventive controls.

3.2 Known or Reasonably Foreseeable Hazards

Animal food can become contaminated with biological, chemical (including radiological), or physical hazards. Table 3-1 contains some examples of biological, chemical, and physical hazards in animal food that may be relevant, depending on the type of animal food (e.g., pet food or livestock food) being manufactured, processed, packed, or held at your facility.

Table 3-1. Examples of Known or Reasonably Foreseeable Hazards

Hazard Category	Hazard Sub-Category	Examples
Biological	Bacteria	*Salmonella* spp. *Listeria monocytogenes* (*L. monocytogenes*) Pathogenic *Escherichia coli* (*E. coli*)
Biological	Parasites	*Toxoplasma gondii* *Cryptosporidium*
Biological	Prions	Prion causing Bovine Spongiform Encephalopathy (BSE)

Hazard Category	Hazard Sub-Category	Examples
Chemical	Pesticide residues	Organochlorines Organophosphates Carbamates
Chemical	Heavy metals	Lead Cadmium Mercury
Chemical	Natural Toxins	Aflatoxin Fumonisin Ochratoxin Plant toxins (glucosinolates) Tissue toxins
Chemical	Drug residues Drug carryover	Animal drugs (e.g., penicillin, pentobarbital) Carryover of ionophores (e.g., monensin) into horse feed
Chemical	Unapproved color and food additives	D&C Red No. 6 Propylene glycol (specifically in cat food) Ethylene glycol Melamine
Chemical	Intentionally introduced for the purpose of economic gain	Triazines (melamine, cyanuric acid)
Chemical	Radionuclides	Radium 226 and 228
Chemical	Environmental	Dioxins Polychlorinated Biphenyls (PCBs) Polyaromatic Hydrocarbons (PAH)

Hazard Category	Hazard Sub-Category	Examples
Chemical	Nutrient deficiencies or toxicities	Minerals (e.g., inadequate calcium or salt (sodium chloride); excess calcium, selenium, or salt) Vitamins (e.g., inadequate thiamine (cat food); excess vitamin D)
Chemical	Industrial chemicals	Cleaning chemicals Non-food-grade lubricants
Physical	Physical	Metal Glass Hard plastic

In your hazard analysis, you must identify and evaluate the known or reasonably foreseeable biological, chemical, and physical hazards related to your animal food (which includes raw materials and other ingredients (ingredient-related hazards)), processes (process-related hazards), and your animal food-production environment (facility-related hazards). See 21 CFR 507.33. Throughout this chapter, we discuss biological, chemical, and physical hazards from the perspective of ingredient-related hazards, process-related hazards, and facility-related hazards.

3.3 Biological Hazards

The biological hazards that are the focus of this guidance are bacterial pathogens (e.g., *Salmonella* spp., *L. monocytogenes*, and pathogenic *E. coli*), and certain parasites (e.g., *Toxoplasma gondii*) that may be associated with animal food or animal food processing operations and that can cause illness or disease in humans or animals. The other biological hazards mentioned in Table 3-1 include other parasites (e.g., *Cryptosporidium* spp.) and prions (e.g., prions causing BSE in cattle). Biological hazards could also include viral pathogens. When conducting your hazard analysis to identify known or reasonably foreseeable hazards, you should consider whether a pathogenic virus is a concern for your facility by reviewing any current scientific evidence and other information about introduction of pathogenic viruses into animal food (e.g., from animal food ingredients, animal food-packaging materials, or transportation vehicles) and transmission of these viruses through animal food.

Animal food can become contaminated with bacterial pathogens. These pathogens can be:

- ingredient-related hazards – i.e., introduced from raw materials and other ingredients
- process-related hazards – e.g., if the pathogens:
    - survive the manufacturing process
    - increase in number due to lack of time/temperature control or due to the animal

food's formulation
    - are introduced into a finished animal food due to loss of container integrity
- facility-related hazards – e.g., if the pathogens are introduced from:
    - insanitary animal food processing equipment
    - cross-contamination between raw and cooked products
    - contaminated air
    - sewage or contaminated water

Table 3-2 is a Quick Reference Guide to help you identify bacteria and parasites and potential sources or entry points in your facility. The hazards listed in Table 3-2 will not apply to all animal food at all facilities.

Table 3-2. Quick Reference Guide for Some Sources of Bacteria and Parasites in Animal Food

Primary Source	Bacteria and Parasites (and Some Example Sources)
Ingredient-related	*Salmonella* spp. (raw meat and poultry, raw eggs or egg product, animal protein product (such as meat and bone meal and fish meal), plant protein products (such as canola meal, soybean meal), fruits and vegetables, and flavor agents) *L. monocytogenes* (raw agricultural commodities) Pathogenic *E. coli* (raw meat, fruits and vegetables, plant protein product) *Clostridium botulinum* *Toxoplasma gondii* (raw meat) *Cryptosporidium* spp. (contaminated water used as an ingredient)
Process-related	*Salmonella* spp. *L. monocytogenes* Pathogenic *E. coli* *Clostridium botulinum*
Facility-related	*Salmonella* spp. (pests, dust, floors, cold wet areas, equipment, drains, condensate, coolers, and soil) *L. monocytogenes* (floors, cold wet areas, equipment, drains, condensate, coolers, and soil)

3.3.1 Foodborne Pathogens Associated with Animal Food

Bacterial pathogens

Bacterial pathogens can be classified based on whether they form spores (sporeformers) or whether they exist as vegetative cells and do not form spores (non-sporeformers). Spores are not hazardous as long as they remain in the spore state. Spores are very resistant to heat, chemicals, and other treatments that would normally kill vegetative cells of both sporeformers and non-sporeformers.

When spores survive a processing step designed to kill vegetative bacteria, they may become a hazard in the animal food if they are exposed to conditions that allow germination and growth as vegetative cells. This can be particularly serious when a processing step has removed most of their competition. Thus, other controls such as reduced pH or a_w or temperature control (refrigeration or freezing) may be needed to control sporeformers that remain following the processing step designed to kill vegetative bacteria. As a result, when spores are a concern, the process steps used to kill them are often much more stringent than those necessary to kill vegetative cells.

***Salmonella* spp.** is the bacterium responsible for salmonellosis in humans and animals. For animals, different animal species typically develop disease in response to different *Salmonella* serotypes. For livestock and poultry food, the following are some examples of the food and the *Salmonella* serotypes that have been associated with disease in the particular animal species consuming the animal food:

- food for poultry with *Salmonella* Pullorum, *Salmonella* Gallinarum, or *Salmonella* Enteritidis
- food for swine with *Salmonella* Choleraesuis
- food for sheep with *Salmonella* Abortusovis
- food for horse with *Salmonella* Abortusequi
- food for cattle with *Salmonella* Newport or *Salmonella* Dublin

We consider animal food for livestock and poultry to be adulterated when it may be injurious to health because it is contaminated with a *Salmonella* serotype that is likely to cause disease in the animal species intended to consume that animal food and the animal food will not subsequently undergo a commercial heat step or other commercial process that will kill the *Salmonella* (see our Compliance Policy Guide (CPG) Sec. 690.800 entitled "*Salmonella* in Food for Animals.")[5] The *Salmonella* serotypes listed above are not commonly found in animal food at manufacturing facilities. Therefore, you may determine that *Salmonella* is not a known or reasonably foreseeable hazard for your animal food, or is not a hazard requiring a preventive control, if you manufacture only livestock or poultry food.

[5] Food and Drug Administration. 2013. "CPG Sec. 690.800 *Salmonella* in Food for Animals." https://www.fda.gov/media/86240/download

We consider all pet food contaminated with any *Salmonella* serotype to be adulterated when the pet food will not subsequently undergo a commercial heat step or other commercial process that will kill the *Salmonella*.[6] Infected dogs and cats can either be asymptomatic or exhibit clinical signs of gastroenteritis. In severe cases, clinical signs can also include fever, dehydration, rapid heart rate, rapid breathing, shock, and death. Infected dogs and cats can shed the bacteria in their feces for up to 6 weeks, whether they are exhibiting clinical signs or are asymptomatic (Ref. 1).

Pet food contaminated with *Salmonella* also poses a significant risk to humans who handle that pet food. In addition, *Salmonella*-contaminated pet food can lead to contamination of surfaces or objects in the home that can result in infections in humans touching these surfaces or objects. *Salmonella* contamination of surfaces or objects in the home can occur, for example, from: (1) contact with the contaminated pet food, (2) contact with the pet (or its feces) that has consumed the contaminated pet food, or (3) a human who has handled contaminated pet food or the infected pet and then subsequently handled the surface or object. Examples of *Salmonella* contaminated surfaces or objects include pet bowls, pet bedding, pet toys, floors, and kitchen surfaces (Ref. 2).

The association between human outbreaks of salmonellosis and *Salmonella*-contaminated pet food is well documented. For example, the CDC reported that from January 1, 2006, to October 31, 2008, 79 human cases of salmonellosis were linked to *Salmonella* Schwarzengrund in dry dog food manufactured by a facility in the U.S. (Ref. 3). In 2012, 49 individuals were infected with *Salmonella* Infantis, which was linked to dry dog food manufactured by a different facility in the U.S. (Ref. 4). In 2019, the CDC reported a multistate outbreak of multidrug-resistant *Salmonella* infections in humans linked to contact with pig ear dog treats. A total of 154 people were infected with the outbreak strains of *Salmonella* (Ref. 5). There also are published reports of transmission of *Salmonella* to humans via contact with *Salmonella*-infected pets (Refs. 6, 7 and 8).

***Listeria monocytogenes* (*L. monocytogenes*)** is the bacterium responsible for listeriosis in humans and animals. Clinical signs of listeriosis in dogs and cats can range from the non-specific such as vomiting, diarrhea, and fever to the more specific signs such as neurological (imbalance or circling), or abortion in a pregnant animal. If the animal becomes septicemic (an infection throughout its body), the clinical signs can range from high fever and lethargy to shock or death.

There have been recalls of *L. monocytogenes* contaminated pet food (e.g., raw dog and cat food) due to the potential to cause listeriosis in humans or pets (Refs. 9, 10, and 11). Transmission of *L. monocytogenes* from contaminated pet food to humans or pets could be similar to transmission of *Salmonella*.

Pathogenic Strains of *Escherichia coli* (*E. coli*) are bacteria associated with foodborne illness in humans and animals. Dogs and cats with foodborne illness caused by pathogenic *E. coli* can be asymptomatic or have symptoms ranging from mild gastroenteritis to hemorrhagic diarrhea.

[6] Ibid

A study conducted to evaluate the prevalence of microbial organisms in various types of pet food found strains of non-O157:H7 Shiga toxin-producing *E. coli* in some raw pet food and jerky type treats (Ref. 12). Transmission of pathogenic *E. coli* from contaminated pet food to humans could be similar to transmission of *Salmonella*.

Clostridium botulinum is a spore-forming bacterium that grows best in low oxygen conditions and can produce toxins (e.g., neurotoxins or enterotoxins). The bacteria form spores that can survive in a dormant state until exposed to conditions that support their germination and growth (e.g., low oxygen conditions). *Clostridium botulinum* is one example. There are seven types of *C. botulinum* designated by letters A through G. Type C is most important in most animal species, but types D, B, and occasionally A and E can be a cause of disease (Ref. 13). Most domestic animals are susceptible to intoxication by *C. botulinum* toxin, however some species are more susceptible (e.g., mink, horses, and cattle) than others (e.g., dogs and cats) (Ref. 14). *C. botulinum* is often found in the intestinal tracts of poultry, cattle, and swine (Ref. 15). Poultry carcasses (and some slaughter by-products) that are manufactured into animal food (such as food for mink) can be a source of botulinum toxin if the animal food is not properly treated (e.g., not heat treated, acidified, refrigerated, or frozen) and a low oxygen condition occurs during production (Ref. 15). Another source of *C. botulinum* has been uneviscerated, salt-cured, whole fish products greater than 5 inches in length. Uneviscerated, salt-cured, whole fish products have caused several outbreaks of botulism and death in humans (see our CPG Sec 540.650 entitled "Uneviscerated Fish Products that are Salt-cured, Dried, or Smoked (Revised)"[7]). In 2018 and 2020, uneviscerated, dried fish greater than 5 inches in length intended for use in pet food were recalled due to the potential to cause illness in pets (Refs. 16 and 17).

C. botulinum toxin could also occur in inadequately processed low-acid canned food (LACF). However, with respect to microbiological hazards, activities subject to 21 CFR part 113 (which covers LACF) are not subject to the requirements in 21 CFR part 507, subparts C and E, provided the facility is in compliance with 21 CFR part 113. See 21 CFR 507.5(b).

Non-bacterial pathogens

***Toxoplasma gondii* (*T. gondii*)** is a parasite that causes toxoplasmosis in humans and many animals (Ref. 18). A common route of transmission in humans is through ingestion of contaminated and undercooked meat. Inadvertent ingestion can also occur through handling contaminated utensils or eating food contaminated by those utensils. Humans also can become infected through indirect ingestion after handling cat feces containing oocysts (a fertilized egg) or from handling anything contaminated with cat feces containing oocysts (e.g., dirt while gardening, eating unwashed fruits and vegetables, or drinking contaminated water). Pregnant women who become infected can pass the infection to their fetus. Immunocompromised people and pregnant women are at the highest risk for toxoplasmosis. Young or immunocompromised animals can also develop clinical infections, causing a variety of diseases depending on the tissues infected (e.g., pneumonia, encephalitis, liver necrosis).

[7] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/cpg-sec-540650-uneviscerated-fish-products-are-salt-cured-dried-or-smoked-revised

A meta-analysis published in 2015, looked at the prevalence of *T. gondii* in food-producing animals used for meat in the U.S. (Ref. 19). The study found *T. gondii* infection is more widespread in lamb, goats, non-confinement-raised chickens, and non-confinement-raised pigs. The consumption of raw meat significantly increases the seroprevalence (i.e., the overall occurrence of a disease in a given population at one time, as measured by blood tests) of *T. gondii* in cats (Ref. 20). This includes cats that are outdoors and hunting prey, but also includes cats fed raw meat-based diets. A pet food manufacturer, especially one making raw pet food for cats, might consider this parasite as a known or reasonably foreseeable biological hazard in meat from the species of animals in which *T. gondii* is more likely to be found.

Transmissible Spongiform Encephalopathy Agents – Transmissible spongiform encephalopathies, or prion diseases, are diseases caused by abnormal, misfolded forms of the prion protein. The prion protein occurs normally in vertebrate animals and is found at highest levels in central nervous system tissues.

Prion diseases of animals in the United States are bovine spongiform encephalopathy (BSE) in cattle, scrapie in sheep and goats, and chronic wasting disease (CWD) in deer and elk. Of the prion diseases, only BSE is transmitted primarily through animal food. BSE transmission can occur when tissues from infected cattle are rendered and the meat and bone meal (MBM) is recycled as an additive in cattle food, and then eaten by non-infected cattle. This type of tissue recycling was banned in the United States in 1997 by FDA's BSE regulation (21 CFR 589.2000), which prohibits the use of mammalian protein, with certain exceptions, in food for ruminants. Though scrapie and CWD are not considered foodborne diseases, the BSE regulation protects against the potential for transmission by this route because it prohibits the use of mammalian protein in food for all ruminant animals, including food for sheep, goats, deer, antelopes, buffalo, and elk.

Measures that exclude mammalian-derived tissue, such as bovine derived MBM, from ruminant feed (including measures that prevent bovine derived MBM entering ruminant feed via cross-contamination during manufacturing and distribution), which are required under 21 CFR 589.2000 and 21 CFR 589.2001, are considered by FDA to be effective against the transmission of the BSE agent. See Chapter 2 – Conducting a Hazard Analysis of this guidance for additional information.

3.3.2 Ingredient-Related Biological Hazards

See Table 3-2 in this chapter of this guidance for information that can help you identify ingredient-related biological hazards that may be associated with specific animal food. See Chapter 4 – Preventive Controls for recommendations on control of biological hazards.

3.3.3 Process-Related Biological Hazards

This section helps you identify process-related biological hazards for the animal food that you produce. Some process-related biological hazards can occur if something goes wrong with a process control. For example, pathogens that you intend to control by heat treatment could

survive if your animal food is not subjected to an adequate time-temperature combination during application of the heat treatment. Also, pathogens that you intend to control by refrigeration could multiply and/or produce toxin if there is a lack of proper refrigeration during animal food holding.

Other process-related biological hazards are not related to something going wrong with a process control. For example, if you use a process control that significantly minimizes (including eliminates) pathogens in a pet food and then add flavoring after the control, pathogens in the flavoring could be introduced into the pet food after the process control step. Also, pathogens could be introduced into animal food after packaging if there is a lack of container integrity.

In the following sections on process-related biological hazards, we describe examples of these kinds of process-related biological hazards. See Chapter 4, section 4.5, for recommendations on control of some specific process-related biological hazards.

Bacterial pathogens that survive process controls

If a process control that you designed to kill bacterial pathogens does not work as intended, the bacterial pathogens, spores, or both that you intended to control can be present in your animal food. See Chapter 4 – Preventive Controls for an overview of recognized and established processing conditions to control pathogens and for factors to consider when designing your process to prevent problems. For example:

- Some animal food does not heat consistently throughout. If the minimum process for lethality is not achieved at the coldest spot of the animal food, pathogens may survive the heat treatment.

- Certain characteristics of animal food make it either easier or harder to destroy bacterial pathogens, if present. For example, it is more difficult to kill pathogens in animal food with high oil content; oils tend to shield pathogens from the effects of heat. The presence of moisture, both in and surrounding the animal food, makes destruction easier. If these characteristics have not been considered in designing the process, pathogens may survive the treatment.

- Different bacterial pathogens have different heat resistances and spores of bacterial pathogens are more heat tolerant than vegetative cells. If the process is not designed to control the most resistant pathogen of concern in the animal food, pathogens may survive the treatment.

Bacterial pathogens that grow

Due to time and temperature abuse

Bacterial pathogens introduced from contaminated ingredients into an animal food that does not undergo a lethality process, or pathogens that survive a lethality process as a result of a problem with a process control, can multiply (grow) and, depending on the pathogen, produce toxin as a result of time and temperature abuse of the animal food. Time and temperature abuse occurs

when animal food is allowed to remain at temperatures favorable to bacterial pathogen growth for sufficient time resulting in unsafe levels of the pathogens or their toxins in the animal food. Animal food that is subjected to time and temperature abuse can support growth of pathogens such as *Salmonella*. For example, holding raw materials and ingredients that require refrigeration at room-temperature for several hours prior to processing can lead to pathogen growth. Time and temperature abuse can cause pathogenic bacteria to grow to such levels that the process control normally used may not be adequate to significantly minimize (which includes eliminating) the hazard.

In evaluating the potential of bacterial pathogens to grow in your animal food, you should consider the following factors:

- the types of pathogenic bacteria that are known or reasonably foreseeable
- whether those pathogens can grow in the animal food
- the expected initial level of the pathogenic bacteria in the animal food

See Chapter 4 – Preventive Controls for an overview of processing conditions to minimize pathogen growth by controlling temperatures to prevent pathogen growth and controlling time of exposure to temperatures at which growth can occur.

Due to poor formulation control

Animal food types most susceptible to biological hazards due to problems with formulation (e.g., pH, a_w, and preservatives) are those that do not undergo a process control that will significantly minimize, or prevent, biological hazards during manufacturing and that may require refrigeration or freezing for safety during their manufacture and shelf life (e.g., some raw or minimally cooked pet food). For these animal food types, product formulation can play an important role in significantly minimizing or preventing hazards. Well-controlled formulation parameters such as pH, a_w, and use of preservatives can work in concert to establish an ecosystem designed to inhibit the growth of the pathogens that may be present.

To determine the potential for a process-related hazard due to poor formulation control, we recommend that you know the formulations or ingredient lists of your incoming ingredients, as well as the equilibrated pH, titratable acidity, a_w, percent moisture and percent sodium, as appropriate, of the finished animal food. Much of the animal food susceptible to biological hazards due to problems with formulation is made up of multiple ingredients, each with its own specific set of formulation parameters. Any individual ingredient not meeting the formulation parameters established to ensure that the preventive control is achieved may result in an animal food that does not inhibit the growth or toxin formation of a pathogen that may be present in the animal food. In determining the potential for a process-related biological hazard due to poor formulation control, we also recommend that you consider the interactions that may occur among the various raw materials and other ingredients when combined. See Chapter 4, section 4.5.3, for an overview of formulation-based controls.

Due to reduced oxygen packaging

From a food safety standpoint, packaging serves two functions: (1) it prevents contamination of the animal food; and (2) it makes possible, or extends the effectiveness of, food preservation methods. For example, packaging can maintain the atmosphere in a controlled or modified atmosphere package or a vacuum package, or it can prevent rehydration of a dried animal food. Modified atmosphere packaging and vacuum packaging methods are grouped into a category that we call reduced oxygen packaging (ROP). ROP is used to prevent the growth of spoilage organisms, thereby extending the shelf life of the product. There are some other product quality benefits as well, such as reductions in rancidity, shrinkage, and color loss.

However, ROP does not control the growth of all bacterial pathogens and can create a process-related biological hazard. The extended shelf life provides more time for toxin production or pathogen growth if pathogens are present and temperatures are suitable for growth. Lower oxygen levels favor pathogens that can grow in the absence of oxygen over the aerobic spoilage organisms that require oxygen for growth. For this reason, you may get toxin production before you get spoilage.

The primary concern with ROP is *C. botulinum*, although there also may be concerns with other pathogens such as *L. monocytogenes*, particularly in refrigerated animal food (e.g., pet food). If you have identified *C. botulinum* as a known or reasonably foreseeable hazard in your animal food, you should not use ROP unless barriers for *C. botulinum* are present. These barriers could include a_w, pH, salt, thermal processing in the final container, and freezing with frozen storage and distribution. Each of these barriers by itself can be effective in the control of *C. botulinum* growth. Refrigeration below 38°F (3.33°C) can prevent growth of all strains of *C. botulinum*, but because temperatures above this are commonly employed for refrigeration, temperature should not be relied on as the only control. Combinations of barriers that individually would not control growth of *C. botulinum* can work together to prevent growth.

For a further discussion on the potential for ROP to create a process-related biological hazard as it relates to human food, see Annex 6 of the 2017 FDA Food Code.[8]

Bacterial pathogens in ingredients added after applying process controls

The manufacture of certain animal food involves, by design, the addition of ingredients after application of process controls. For example, flavorings and fats may be added after extrusion (i.e., the process control) but prior to packaging in the production of some pet food. A facility that produces animal food containing ingredients added after a process control should consider the potential for the added components to be a source of a process-related biological hazard as part of its hazard analysis.

Bacterial pathogens introduced after packaging due to lack of container integrity

Animal food manufactured and processed (e.g., heat treated) in a container or clean filled after treatment can become contaminated if its container loses seal integrity, thereby exposing the processed animal food to biological hazards. Poorly formed or defective container closures can

[8] https://www.fda.gov/food/fda-food-code/food-code-2017

increase the risk of microbial pathogens entering the container through container handling that occurs after the product has been filled and the container has been sealed.

3.3.4 Facility-Related Biological Hazards

Facility-related biological hazards in animal food could occur from exposure or contact with contaminated equipment during procedures such as conveying, mixing, cooling, or packaging. In addition, animal food that is subjected to a preventive control (e.g., heat treatment, high pressure processing) to significantly minimize pathogens identified as hazards requiring a preventive control, may be recontaminated through exposure to a facility environment that contains these pathogens (Ref. 21). As discussed in the following sections on facility-related biological hazards, there are challenges to preventing recontamination.

The PCAF requirements specify that your hazard evaluation must include an evaluation of environmental pathogens whenever an animal food is exposed to the environment prior to packaging and the packaged animal food does not receive a treatment or otherwise include a control measure (such as a formulation lethal to the pathogen) that would significantly minimize the pathogen (see 21 CFR 507.33(c)(2)). See 21 CFR 507.3 for the definition of "environmental pathogen." In the following sections, we provide information on potential sources of facility-related environmental pathogens in different types of animal food facilities.

Effectively designed and implemented CGMPs are key to keeping biological hazards out of your animal food. However, the application of CGMPs cannot guarantee that a processed animal food will not become contaminated from the environment. This is one reason why the PCAF requirements specify that sanitation controls include procedures, practices, and processes to ensure that the facility is maintained in a sanitary condition adequate to significantly minimize or prevent hazards such as environmental pathogens (see 21 CFR 507.34(c)(2)). To verify implementation and effectiveness of a sanitation control, the PCAF requirements specify that (as appropriate to the facility, the animal food, and the nature of the preventive control and its role in the facility's animal food safety system) you must conduct activities that include environmental monitoring for an environmental pathogen or for an appropriate indicator organism, by collecting and testing environmental samples, if contamination of an animal food with an environmental pathogen is a hazard requiring a preventive control. See 21 CFR 507.49(a)(3).

Sources of facility-related biological hazards

The likelihood of product contamination with a facility-related environmental pathogen increases as the prevalence of the environmental pathogens in the processing environment increases. The prevalence of the environmental pathogens in the processing environment can be influenced by the raw materials used in the process, the type of process, and the hygienic practices applied to keep the processing area clean and, as necessary, sanitized. Table 3-3 is a guide to help you identify some of the sources of facility-related biological hazards that can contaminate the animal food processing environment; Table 3-3 does not provide an exhaustive list of such sources.

Table 3-3. Some Sources and Modes of Contamination of Facility-Related Biological Hazards

Source	Modes of Contamination
Raw agricultural commodities and other ingredients (e.g., raw meat and poultry, raw milk, raw offal, oil seeds, fruits and vegetables, meat and bone meal)	Transfer of biological hazards from the ingredient to equipment and utensils Transfer of biological hazards from the ingredient to personnel handling the ingredient Inadequate cleaning of containers used to store ingredients containing hazards
Food handlers and maintenance personnel	Transfer of biological hazards from one point to another on their person (e.g., shoes and other clothing) Improper hand washing Transfer of biological hazards to animal food through improper handling or maintenance practices (e.g., insufficient cleaning and sanitizing animal food-contact surfaces after equipment maintenance)
Air and water	Lack of appropriate air filtration for cooling, drying, air conveying Improper air flow from raw materials and other ingredients areas to finished animal food areas Aerosols from improper cleaning practices
Insects and pests (e.g., flies, cockroaches, rodents)	Transfer of biological hazards from outside the facility or from one point to another in the facility as pests travel Contact with finished animal food
Transport equipment (e.g., forklifts, racks, carts, conveyor belts)	Transfer of biological hazards throughout the facility via wheels on equipment Cross-contamination from using the same equipment for ingredients and finished animal food

Transient and resident facility-related environmental pathogens

Once bacterial pathogens have been introduced into the processing environment, experience has shown that pathogens may be present as transient contamination or as resident contamination within a facility.

Transient contamination

Bacterial pathogens, including environmental pathogens, are typically introduced into the processing facility through incoming raw materials and other ingredients, personnel, or pests. It is important to ensure that these microorganisms remain transient and do not become established in the environment where they can grow and multiply. Transient contaminants can, however, result in a diversity of pathogens in the processing environment that can show up in the processing lines and finished animal food. This phenomenon could occur in animal food operations using a wide variety of raw materials and other ingredients (e.g., raw meat, meat and bone meal, canola meal) because these materials can contain very diverse microflora. In general, routine cleaning and sanitizing in accordance with CGMPs is adequate to protect against contamination by transient bacteria in the processing facility.

Resident contamination

Bacterial pathogens causing resident contamination can also be introduced into the processing facility, where the pathogens then become established in a harborage site, multiply, and persist for extended periods of time, even years. A harborage site, or niche, is a site in the environment or on equipment (e.g., junctions, cracks, holes, and dead-end areas) that enables the accumulation of residues (e.g., animal food debris, dust, and water) and permits the growth of microorganisms such as *Salmonella* and *L. monocytogenes*. These sites may be difficult to inspect or access and therefore can help protect environmental pathogens during routine cleaning and sanitizing. While routine cleaning and sanitation practices are adequate to protect against the presence of transient contaminants, such practices do not control the presence of resident contaminants once they have become established. Sanitation controls, including proper personnel practices, and good equipment and facility design are important in preventing transient bacterial pathogens from becoming resident strains.

Once an environmental pathogen has become established as a resident contaminant, there is a persistent contamination risk for animal food processed in that facility. Intensified sanitation procedures will be needed to significantly minimize the contamination. *Salmonella* and *L. monocytogenes* are the pathogens most likely to set up residence in animal food processing facilities. Also, the potential exists for other pathogens (e.g., pathogenic *E. coli*) to become established as resident contaminants.

Key determinants for the pathogens to become established in an animal food processing environment are: (1) the temperature at which the animal food processing environment is maintained; (2) the available moisture in the animal food processing environment; and (3) the availability of nutrients for growth. For processed animal food, this typically translates into two primary categories of animal food processing environments:

- frozen/refrigerated and wet
- warm/ambient and dry

In both cases, proper cleaning is needed to minimize nutrient availability for growth of environmental pathogens. The pathogen most often associated with cold and wet processing environments is *L. monocytogenes,* and the pathogen most often associated with warm and dry processing environments is *Salmonella* (Refs. 22 and 23).

Facility-related environmental pathogens associated with wet and dry processing environments

Animal food processing operations can generally be classified into one of two simple categories – wet processing environments or dry processing environments (Table 3-4). This very simple distinction has significant implications for the best strategies for controlling animal food contamination from environmental pathogens.

Table 3-4. Some Examples of Animal Food Processed in Wet and Dry Processing Environments

Processing Environment Conditions	Examples of Animal Food
Wet	Frozen raw pet food Refrigerated pet food
Dry	Milk powders Extruded animal food Rawhide pet chews/treats Jerky treats Dehydrated animal food Meat and bone meal Freeze-dried raw pet food

Wet processing environments

The most effective strategy to prevent the contamination of finished animal food with *L. monocytogenes* is to maintain an environment as dry as possible. Wet environments have some obvious characteristics that can lead to contamination by *L. monocytogenes*, such as:

- wet floors due to constant wet cleaning will facilitate the transfer of *L. monocytogenes* from an environmental source to animal food-contact surfaces

- wet floors can create harborage sites if they are not well maintained and have broken or cracked grout or tiles. These structures may provide protected harborage to environmental pathogens even when the floors are cleaned and sanitized

- condensation on overhead structures as a result of air temperature and humidity control issues and from use of water in heating and cooling operations creates a means of transfer of *L. monocytogenes* from non-animal food-contact surfaces to exposed animal food and animal food-contact surfaces

- frost formation due to condensation at freezer entry and exit points provides an opportunity for moisture accumulation and a constant source of water in which *L. monocytogenes* can multiply

Wet floors can serve as potential vectors for *L. monocytogenes* via the movement of people and equipment and material handling items such as totes and pallets. For example, wet floors can serve as a potential vector for pathogen transfer when personnel walk through standing water on poorly designed floors and drains and during cleaning. *L. monocytogenes* is not usually airborne; however, in wet environments, aerosols from high pressure water hoses used during cleaning operations help spread *L. monocytogenes* throughout the environment and from one surface (e.g., floors) to another surface (e.g., animal food-contact surfaces such as conveyors, tables, and animal food containers). In many facilities, certain processing operations are inherently wet such as raw material preparation and mixing and formulation of liquid components. In these cases, we recommend that you use personnel, equipment traffic, and cleaning practices that minimize water accumulation and aerosol formation to prevent in-process and finished animal food recontamination.

We recommend that wet processing areas be dried out as much as possible. This could be a challenge for some segments of the animal food industry that depend on the unlimited use of water for equipment and facility cleaning practices.

Dry processing environments

Environmental moisture control is critically important in preventing *Salmonella* contamination in low-moisture products (Ref. 23). Water in the dry processing environment is one of the most significant risk factors (perhaps the single most important factor) for *Salmonella* contamination because water allows for pathogen growth, significantly increasing the risk for animal food contamination. Water, present even in very small amounts for short, sporadic time periods, may allow *Salmonella* to grow in the environment. Moisture may be obvious from sources such as water droplets or puddles from wet cleaning, but not so obvious from sources such as high relative humidity or moisture accumulating inside equipment.

Salmonella can, to varying degrees, be introduced into low-moisture food manufacturing facilities and become established in those environments. Once water enters a harborage site, microbial growth can occur and the potential risk of contamination of the environment and of the product is increased. (Ref. 24).

The presence of water in the dry processing environment can result from improper use of water during cleaning and can enhance the probability of contamination from pathogens such as *Salmonella* (Ref. 24). Other sources resulting in the presence of water in a dry area include condensate formation, leaking water or steam valves, infiltration of water following heavy rains (e.g., leaky roofs), and the use of water during fire emergencies. We recommend that you remove water immediately from the primary *Salmonella*-controlled hygiene areas (areas where animal food that will not undergo a lethality process is exposed to the environment) following such events to keep the plant environment as dry as possible.

You should maintain dry conditions at all times in primary *Salmonella*-controlled hygiene areas, except for the occasions when you have determined that controlled wet cleaning is necessary. Potential problems arise when there is visible water present in the dry areas or when there are areas in which standing water has dried. *Salmonella* may be found both in wet spots and in spots where standing water has dried (Ref. 25). The latter situation may present an additional risk of spread via the generation of airborne contaminated dust (Ref. 21).

3.4 Chemical Hazards

The chemical hazards that are the subject of this guidance include chemical hazards that are natural components of ingredients (e.g., glucosinolates) or natural toxins (e.g., mycotoxins), contaminants of raw materials and other ingredients (e.g., pesticides and drug residues), and chemical hazards as a result of manufacturing errors (e.g., nutrient deficiencies or toxicities). Animal food can become contaminated with chemical hazards that can be:

- ingredient-related hazards – that is, introduced from raw materials and other ingredients such as natural toxins or contaminants on or in ingredients
- process-related hazards – e.g., from manufacturing errors, or cross-contamination
- facility-related hazards – e.g., from chemicals used on animal food processing equipment or utensils, or chemicals stored in the facility

Some chemical hazards may cause immediate effects (e.g., gastrointestinal symptoms, shock, or death), such as those caused by industrial chemicals (e.g., caustic cleaning compounds). Other chemical hazards may cause more chronic effects after long-term exposure to the chemical (e.g., weight loss, depression, liver failure, neurological disease, or cancer) such as those caused by lead or some mycotoxins.

An example of a range of acute to chronic toxic effects can be seen in sheep fed animal food with excess levels of copper (Refs. 26 and 27). Acute toxic effects in sheep include sudden onset of abdominal pain, diarrhea, loss of appetite, shock, or death. Chronic toxic effects of copper in sheep include similar symptoms to acute exposure, but present over a longer period of time. Chronic toxic effects in sheep also include difficulty breathing, jaundice, and death.

FDA has set action levels and tolerances for some chemical contaminants in animal food in our GFI entitled "Action Levels for Poisonous or Deleterious Substances in Human Food and

Animal Feed."[9] These levels represent limits at or above which FDA may take legal action to remove products from the market. Where no established action level or tolerance exists, FDA may take legal action against the product at the minimal quantifiable (or in some cases detectable) level of the contaminant. Action levels and tolerances are established based on the unavoidability of the poisonous or deleterious substances and do not represent permissible levels of contamination where it is avoidable. FDA has established temporary tolerances for polychlorinated biphenyls (PCBs) in animal food and food packaging material (see 21 CFR 509.30).

Under the FD&C Act, certain substances, such as food additives, color additives, and new animal drugs, require premarket approval before they may be legally used. Approval for food additives, color additives, and new animal drugs can have limitations so that the substance can only be used legally on or in animal food for specific purposes, specific species, or for a specific life stage or production class.

Chemical substances in an animal food are not always considered hazards and their occurrence may be unavoidable. The particular chemical and its level in the animal food (depending on the species, life stage, or production class the animal food is intended for) are factors to consider in determining whether the chemical is a hazard. The preventive controls that you identify and implement for controlling specific chemical hazards should be based on the characteristics of the chemical and how the chemical is introduced into your animal food.

For additional information on the control of chemical hazards, see Chapter 4, section 4.6.

In the remainder of this section on chemical hazards, we briefly describe characteristics of some chemical hazards that can be present in animal food and processing environments, including ways they can be introduced into animal food. Effectively designed and implemented CGMPs can be key to keeping many process-related chemical hazards and facility-related chemical hazards out of your animal food.

Table 3-5 is a guide to help you identify some sources of chemical hazards when conducting your hazard analysis. This is not an exhaustive list.

[9] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-action-levels-poisonous-or-deleterious-substances-human-food-and-animal-feed.

Table 3-5. Quick Reference Guide for Some Sources of Chemical Hazards

Source	Examples
Ingredient-related chemical hazards	Pesticide residues and mycotoxins on raw agricultural commodities and grains Heavy metals in or on raw agricultural commodities or in mineral ingredients or premixes Natural toxins (e.g., glucosinolates in the Brassicaceae family) Animal drug residues Unapproved food or color additives Radiological hazards Dioxins
Process-related chemical hazards	Nutrient deficiencies or toxicities due to manufacturing error Radiological hazards from use of contaminated water supply Animal drug carryover from medicated to non-medicated animal food Food or color additives not approved for certain species due to incomplete cleanout of equipment
Facility-related chemical hazards	Contamination with industrial chemicals such as cleaners or sanitizers Chemicals not used in processing animal food but stored in the facility such as fertilizers Heavy metals due to leaching from containers or utensils

3.4.1 Ingredient-Related Chemical Hazards

Pesticides

Pesticide chemical residues may be of concern in food crops and in foods of animal origin. The term "pesticide chemical" is used for any substance (with certain exceptions) that is a pesticide within the meaning of the Federal Insecticide, Fungicide, and Rodenticide Act (see FD&C Act, § 201(q)). Pesticides (e.g., insecticides, fungicides, rodenticides, insect repellants, herbicides, and some antimicrobials) are designed to prevent, destroy, repel, or reduce pests (Ref. 28).

All pesticide chemicals sold or distributed in the United States must be registered by the Environmental Protection Agency (EPA). See 40 CFR part 180. The EPA also establishes tolerances (maximum amounts) for pesticide chemical residues in or on food. Pesticide chemical residues in or on food render the food adulterated under section 402(a)(2)(B) of the FD&C Act

unless EPA has set a tolerance for that residue in or on that food and the residue quantity is within that tolerance limit or there is an exemption from the tolerance requirement for that residue (see FD&C Act, § 408(a)(2)(B)). FDA and the USDA enforce tolerances in food under their jurisdiction, using a memorandum of understanding to coordinate activities among FDA, USDA, and EPA (Ref. 29). A detailed description of how FDA enforces tolerances for pesticide chemical residues in animal food is available in FDA's CPG Sec. 575.100 entitled "Pesticide Residues in Food and Feed - Enforcement Criteria."[10] For more information regarding pesticide chemical residues and the FDA Pesticide Residue Monitoring Program, see the annual reports available on FDA's website.[11]

Reasons for adulteration of animal food products with a pesticide chemical residue are the improper treatment of a raw agricultural commodity with a registered pesticide or the raw agricultural commodity being exposed to non-registered pesticides.

Heavy metals

Heavy metals are naturally occurring elements such as lead, arsenic, cadmium, and mercury. Increased levels of heavy metals in the environment are often a result of industrial and agricultural practices (e.g., use of pesticides containing heavy metals, use of manure as a fertilizer, or release of industrial waste) (Ref. 30). Mercury is known to accumulate in certain fish species. One study of food found mercury concentrations in tested cat and dog food that ranged from 1 to 604 nanograms per gram (ng/g). The pet food samples with the highest concentrations of mercury all contained fish as the primary ingredient (Ref. 31). Though not environmental, another potential source of contamination of animal food during manufacturing is the leaching of heavy metals from containers or utensils that come in contact with the animal food.

Mineral supplements and premixes for animal food have been found to be a common source of high levels of heavy metals (Refs. 32 and 33). Raw minerals are typically mined or recycled. Mineral ore deposits are often a mixture of several different inorganic forms of the mineral and may include several other minerals as well as contaminants. For example, in some regions, lead is a natural contaminant of calcium carbonate (limestone) (Ref. 34).

Consumption of animal food contaminated with heavy metals can cause adverse health consequences to the animal. For example, lead exposure in birds can cause anorexia, loss of condition, wing and leg weakness, and anemia. In dogs, lead exposure presents predominantly as gastrointestinal abnormalities; however, anxiety, hysterical barking, jaw champing, salivation, blindness, ataxia, muscle spasms, and convulsions may develop (Ref. 35). Whether an animal develops an injury or illness as a result of exposure to minerals (including heavy metals) depends upon the species, level of the mineral in the animal food, and frequency of exposure (Ref. 26).

Information on heavy metals in animal food is available (Refs. 26, 36, and 37). If you have identified one or more heavy metals as a known or reasonably foreseeable hazard for your

[10] https://www.fda.gov/media/75151/download

[11] https://www.fda.gov/food/pesticides/pesticide-residue-monitoring-program-reports-and-data

animal food, we recommend you review multiple references for your hazard analysis. These resources may recommend different maximum levels of a heavy metal in animal food for the same species depending on the parameters of the safety review conducted. You should use the lowest maximum level of the heavy metal recommended by the resources when establishing your preventive control. You should ensure the reference that you use takes into consideration both animal food and human food derived from animals, if appropriate.

Natural toxins

Mycotoxins

Natural toxins (i.e., naturally occurring toxins), such as mycotoxins, are recognized as hazards in raw or processed agricultural commodities. The term "mycotoxins" is used for a group of natural toxins which include, among others, aflatoxins, fumonisins, deoxynivalenol (vomitoxin), zearalenone, ochratoxin, and ergot alkaloids, that are recognized as hazards in raw or processed agricultural commodities. Mycotoxins are toxic secondary metabolites produced by certain fungi (i.e., molds) that can infect raw agricultural commodities (e.g., grains, fruits, and nuts) and proliferate in the field and during storage.

The occurrence of mycotoxins in raw agricultural commodities is not entirely avoidable. Occurrence of these toxins on commodities susceptible to mold infestation is influenced by environmental factors such as temperature, humidity, and extent of rainfall during the pre-harvesting, harvesting, and post-harvesting periods. The molds that produce mycotoxins typically grow and become established in the raw agricultural commodity during stressful growing conditions (e.g., when there is insect damage to the crop or a drought) and holding conditions (e.g., wet storage from condensation).

Mycotoxins may produce various toxicological effects. Some mycotoxins are teratogenic, immunotoxic, mutagenic, or carcinogenic and are associated with various diseases in susceptible animal species and humans. The FDA has set species specific recommended maximum levels for aflatoxins, fumonisins, and deoxynivalenol in some animal food (Table 3-6). FDA has not established levels for other mycotoxins such as ochratoxin and zearalenone. When these mycotoxins are found in animal food the FDA reviews each finding on a case-by-case basis.

Hazardous levels of mycotoxins have been found in individual ingredients as well as finished animal food. When mycotoxins are found in individual ingredients, FDA guidance (included in Table 3-6 below) may be used to identify if the ingredient may safely be used in food for different species. For example, corn containing 20 parts per billion (ppb) or more aflatoxin should not be used in animal food for dairy animals since it could result in unsafe residues of aflatoxin in milk (greater than 0.5 ppb). Aflatoxin levels at or below 300 ppb in corn can be used in animal food for finishing beef cattle because the level does not pose a health concern for the beef cattle or to humans consuming food derived from the beef cattle.

Table 3-6. Mycotoxins Associated with Ingredients Used in Animal Food

Mycotoxins	Ingredients in which the Mycotoxin may be Found	Related Guidance
Aflatoxins	Corn, Cottonseed, Peanuts	CPG Sec. 683.100 entitled "Action Levels for Aflatoxins in Animal Feeds"[12]
Fumonisins	Corn	GFI #112 entitled "Fumonisin Levels in Human Foods and Animal Feeds"[13]
Deoxynivalenol (Vomitoxin)	Wheat, Barley	Guidance for Industry and FDA entitled "Advisory Levels for Deoxynivalenol (DON) in Finished Wheat Products for Human Consumption and Grains and Grain By-Products used for Animal Feed"[14]
Ochratoxin	Oats, Wheat, Flax (Linseed), Soybean Meal	Reviewed on a case-by-case basis
Zearalenone	Grains (e.g., wheat, barley, oats)	Reviewed on a case-by-case basis

Mycotoxins are not significantly degraded by food processing and can contaminate finished processed animal food (Ref. 38). In 1998, 2005, 2011, 2013, 2020, and 2021 aflatoxin contamination of dog and cat food resulted in illness, dog mortalities, and extensive recalls of affected dog and cat food (Refs. 39, 40, 41, 42, 43, and 44).

Plant toxins

Plants are known to produce a number of toxicants and anti-nutritional factors, such as protease inhibitors, hemolytic agents, and neurotoxins, which often serve the plant as natural defense compounds against pests or pathogens. An anti-nutritional factor, or anti-nutrient, is a naturally-occurring substance found in plant-derived foods that interferes with absorption or proper functioning of nutrients in the body (Ref. 45). For example, most cereal grains contain protease inhibitors, which can diminish the nutritive value of proteins. For the purpose of this guidance, anti-nutritional factors are included in plant toxins as they are known or reasonably foreseeable

[12] https://www.fda.gov/media/121202/download

[13] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-fumonisin-levels-human-foods-and-animal-feeds

[14] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-and-fda-advisory-levels-deoxynivalenol-don-finished-wheat-products-human

hazards associated with some ingredients.

There are a variety of plant toxins with different health effects. Many legumes contain relatively high levels of lectins and cyanogenic glycosides. Lectins, if not destroyed by cooking or removed by soaking, can cause severe nausea, vomiting, and diarrhea. The levels of cyanogenic glycosides in cassava and some legumes can lead to death or chronic neurological disease if these foods are eaten uncooked (Ref. 46). Plants from the family Brassicaceae contain glucosinolates which may be deleterious to animal health such as impairing thyroid function in many species (Ref. 47).

Some plant-based ingredients, including those plant ingredients that may contain natural toxins, are approved as food additives (see discussion below *Unapproved Color and Food Additives*). A food additive regulation may specify a method of manufacture, restrict the intended animal species, restrict the percentage of the food additive in a finished animal food, set a maximum level of the natural toxins, or a combination of these measures. For example, the approval for heat toasted crambe meal specifies, among other things, that glucosinolate calculated as epiprogoitrin cannot be more than 4 percent of the meal by weight. The approval also restricts use to feed for feedlot cattle as a source of protein in an amount not to exceed 4.2 percent of the total ration (see 21 CFR 573.310).

Tissue toxins

The presence of thyroid gland tissue in cattle and lamb products has been associated with exogenous thyrotoxicosis (hyperthyroidism) in humans due to bioactive thyroid gland hormones (Ref. 48). For this reason, USDA prohibits the use of thyroid glands and laryngeal muscle tissue for human food (Ref. 49).

Cases of exogenous thyrotoxicosis in dogs have been associated with pet treats that contained detectable thyroid hormones (Ref. 50). In early 2017, FDA received reports of ill dogs that, upon further investigation, resulted in the recall of two different brands of dog food because of elevated levels of thyroid hormone (Refs. 51 and 52). Laryngeal tissue (gullets) obtained from beef and lamb slaughter establishments used in the manufacture of pet treats could be a potential source of thyroid tissue that could result in thyrotoxicosis in pets. Removal of the thyroid gland does not ensure that all thyroid tissue is eliminated from the gullet. Because of this potential hazard, New Zealand restricts the use of tissue from the thyroid gland or surrounding structures (larynx) in pet food (Ref. 53). In 2017, FDA provided letters to industry and to veterinarians with information on thyroid hormones in pet food (Refs. 54 and 55). When identifying known or reasonably foreseeable hazards, pet food and pet treat manufacturers should determine whether laryngeal tissue (gullet) is included in their source material and thus could result in thyrotoxicosis in pets consuming food or treats derived from this material.

Animal drugs

Animal drugs can be chemical hazards introduced into your animal food such as through an ingredient containing residues (ingredient-related chemical hazard) or through drug carryover or cross contamination during manufacturing (process-related chemical hazard). An example of an

ingredient-related hazard is drug contamination in an animal food as a result of using a raw material that contains drug residues. A drug contamination that is a result of a process-related hazard typically is the result of cross-contamination of animal food from either incorrect sequencing of medicated feeds or incorrect cleanout of equipment between batches of medicated and non-medicated animal food. See section 3.4.2 for process-related drug contamination.

Animal drug residues in ingredients

In the United States, animal drugs require approval by FDA before they can be marketed for administration to animals. For animal drugs used in food-producing animals, FDA establishes a tolerance for the drug residue in human food as part of the approval process. Animal drug residues detected in food derived from food-producing animals (i.e., animal tissues such as meat, milk, and eggs) are considered a hazard for human food if an established animal drug tolerance is exceeded.

Many slaughter products not used in human food (e.g., not fit for human consumption for various reasons) are used in animal food. Animal food derived from meat, organs (e.g., liver, kidney, heart, brain, and thymus), fat, or skin may contain drug residues (Ref. 56). Although the metabolism and elimination of drugs may vary widely within and between species, as a general rule, the highest drug concentrations will be found in the liver or kidney (e.g., penicillin in kidneys or sulfa drugs in liver). Depending on the chemical property of the drug, residues of certain drugs may become concentrated during animal food manufacturing and processing. For example, drugs that are highly lipid soluble will often be found at the highest concentration in animal food rich in fats/oils. In 2013, two companies recalled various pet treats after antibiotic residues were found upon testing of the treats by a New York State laboratory (Ref. 57). In 2014, FDA issued an import alert for poultry jerky-type treats due to the presence of antibiotic and/or antiviral residues as a result of positive test results for these residues in jerky treats from certain countries (Ref. 58).

Another example of a drug residue in animal tissues is pentobarbital, which is a component of euthanasia solutions that are used to humanely kill animals. Pentobarbital is not approved for euthanasia use in food-producing animals. Animal food that contains a detectable level of pentobarbital, using an FDA validated method, is considered adulterated under § 402(a)(2)(C)(ii) of the FD&C Act. Pentobarbital residues in animal tissues are most likely the result of euthanasia of horses or other animals not intended for human consumption. Pentobarbital is stable in tissue, aqueous environments, and resists degradation at rendering temperatures (Refs. 59 and 60). There are reports of pentobarbital toxicosis in domestic species, zoological animals, and wildlife (Refs. 61, 62, and 63). In 2015, cases of toxicosis linked to pentobarbital in horsemeat resulted in the death of two animals and illness of a third in a wildlife preservation center in the United States (Ref. 64). In 2017, pentobarbital in dog food resulted in illness in four dogs and the death of a fifth dog (Ref. 65).

Pentobarbital residues should be identified as a known or reasonably foreseeable hazard for facilities that salvage skeletal muscle, organs, or other tissues from animals that died other than by slaughter if the cause of death is unknown, or the animal was known to be euthanized with chemicals. The salvaged skeletal muscle, organs or other tissues are generally used for food for

carnivorous animals such as those at zoos, wildlife rehabilitation centers, private wildlife preservation centers, alligator farms, mink farms, or in pet food products. We recommend operations that salvage skeletal muscles, organs, or other tissues for processing determine whether animals have been euthanized using pentobarbital and, if so, exclude those animals from use as animal food.

Unapproved color and food additives

Any substance/ingredient intentionally added to an animal food must be used in accordance with a food additive regulation (see 21 CFR part 573), unless it is generally recognized as safe (GRAS) among qualified experts for its intended use as described in 21 CFR 570.30. Substances that are GRAS for their intended uses in animal food are listed in 21 CFR parts 582 and 584.[15] A substance that is a color additive must be used in accordance with a color additive listing (see 21 CFR parts 73 and 74). If a color additive listed in 21 CFR part 74, subpart A, is used, ensure that the batch has been certified in accordance with 21 CFR part 80. If the batch is not certified, the color additive is considered unapproved for use in food. Under the PCAF regulation, an unapproved food or color additive is a chemical hazard (see 21 CFR 507.33(b)(1)(ii)).

The Association of American Feed Control Officials (AAFCO) Official Publication contains feed (animal food) ingredients and their definitions (Ref. 36). The Official Publication includes FDA approved animal food additives, as well as substances that are GRAS for an intended use in animal food. Other ingredients in the Official Publication are not approved animal food additives and may not meet the criteria to be GRAS for a use. Nevertheless, we do not intend to take enforcement action against these other ingredients in the AAFCO Official Publication for their marketing in interstate commerce, provided there are no food safety concerns about the use or composition of the ingredient that would render the food adulterated under section 402 of the FD&C Act.

Some food and color additives are specifically prohibited from use in animal food because the additives pose a potential risk to public health or have not been shown by adequate scientific data to be safe for use in such food or feed (see 21 CFR part 589, and 21 CFR 81.10). Examples of such food and color additives are gentian violet (see 21 CFR 589.1000), propylene glycol in or on cat food (see 21 CFR 589.1001), and FD&C Red No. 4 (see 21 CFR 81.10(d)). We consider a prohibited food additive or color additive to be an unapproved food additive or color additive for the purposes of the PCAF regulation and thus a chemical hazard.

The use of a substance (whether a GRAS substance or a food additive) in human food does not mean it is GRAS or approved as a food additive for use in animal food. In fact, the substance may be harmful if used in animal food. One example is xylitol, which is found in human foods such as chewing gum, sugar-free nut butters, and some baked goods. However, xylitol is toxic to dogs and if ingested can cause severe hypoglycemia, liver disease, or death (Ref. 66).

[15] These regulations do not identify all substances that are GRAS because it is impractical for FDA to compile a comprehensive list. Under FDA's Animal Food GRAS Notification Program, individuals and firms may voluntarily notify FDA if they have concluded that an animal food substance is GRAS for a particular use. For more information, see the animal food "Generally Recognized as Safe (GRAS) Notification Program" webpage at https://www.fda.gov/animal-veterinary/animal-food-feeds/generally-recognized-safe-gras-notification-program.

Chemical hazards that may be intentionally introduced for purposes of economic gain

The PCAF requirements specify that you must consider, as part of your hazard identification, known or reasonably foreseeable hazards that may be intentionally introduced for purposes of economic gain (21 CFR 507.33(b)(2)(iii)). We recommend that you focus on past patterns of adulteration, that could suggest a potential for intentional adulteration, recognizing that the past occurrences may not be associated with your supplier or your exact type of animal food. To determine if a hazard that may be intentionally introduced for purposes of economic gain is a hazard requiring a preventive control, we recommend that your hazard analysis consider the country of origin of an ingredient that may contain the hazard and any specific supplier associated with an ingredient containing that hazard.

One historical example of intentional adulteration for the purpose of economic gain in animal food was the addition of melamine and other triazines into plant protein ingredients (e.g., wheat gluten and rice protein concentrate) exported to the United States in 2007 by firms in China (Ref. 67). The adulterated plant protein ingredients were used in the manufacture of pet food. This adulteration resulted in a massive pet food recall and illness and death of many dogs and cats. The melamine adulterated pet food also ended up in food for poultry, swine, and food-producing fish. This raised concerns about the safety of human food products derived from those food-producing animals and resulted in the quarantine of thousands of animals until a risk assessment was completed (Ref. 68). Melamine was also intentionally used by one country in milk products (for human food), though none of the milk products were exported to the United States (Ref. 69).

The repeated use of melamine over the years, in animal and human food, demonstrates that patterns of economically motivated adulteration can emerge and should be considered as part of a hazard analysis. If you identify melamine as an economically motivated chemical hazard in your animal food, you need to determine whether melamine is a hazard requiring a preventive control (see 21 CFR 507.33). In particular, you should consider this economic adulterant when using plant protein ingredients from a country where melamine adulteration has occurred.

Sources for information about economically motivated adulteration include an on-line food fraud database and food fraud mitigation guidance made available by the U.S. Pharmacopeia Convention (Ref. 70), and a report from the Congressional Research Service (Ref. 71).

Radiological hazards

Contamination of animal food by radionuclides (a radiological hazard) is a rare event. The most common way these radionuclides are incorporated into animal food is through the use of water that contains the radionuclides. This water may be an ingredient in the animal food or used during the manufacturing process such as for washing ingredients or equipment. There are areas in the United States where high concentrations of some radionuclides, such as radium-226, radium-228, and uranium, can be detected in well water (Refs. 72 and 73). In those regions, radiological hazards could be considered a known or reasonably foreseeable hazard for animal food operations using well water.

Radiological hazards also may result from accidental contamination, e.g., contamination arising from accidental release from a nuclear facility or from damage to a nuclear facility from a natural disaster. You should be vigilant regarding accidental releases of radiological hazards and their potential to contaminate your animal food, either directly due to contamination of natural resources near your facility, or as a result of raw materials and other ingredients that you obtain from a region that has experienced an accidental release of radiation.

Environmental chemical contaminants

Environmental contaminants like dioxins, polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons (PAHs) are chemical hazards that have the potential to be introduced into your animal food either through an ingredient (e.g., clay anti-caking agents), or during manufacturing (e.g., contaminated water source) (Ref. 74). Some of the dioxin and PCB congeners may be carcinogens at low levels of exposure over extended periods of time. Currently there are no tolerances established by the FDA for dioxins in animal food. However, temporary tolerances for residues of PCBs in animal food can be found in 21 CFR 509.30.

Environmental contaminants such as dioxins can get into water from emissions from waste incineration and other combustion that get deposited into bodies of water; and discharges into water from chemical factories (Ref. 75). Over the past decade, EPA and industry have been working together to dramatically reduce the presence of dioxins in the environment. Dioxins, however, are extremely persistent compounds and break down very slowly; thus, current exposures to dioxins in the United States are due to decades-old releases.

3.4.2 Process-Related Chemical Hazards

Some process-related chemical hazards, such as drug carryover, are unintentionally introduced into animal food through cross-contamination due to incomplete cleanout of equipment. Other process-related chemical hazards are caused by animal food manufacturing errors resulting in nutrient deficiencies or toxicities. As discussed previously, some ingredient-related chemical hazards can also be process-related chemical hazards.

Animal drug carryover in animal food

Many feed mills manufacture animal food that contains one or more approved animal drugs. Such animal food is commonly known as medicated feed. These medicated feeds are subject to 21 CFR part 225 – Current Good Manufacturing Practice for Medicated Feeds. Part 225 requires, among other things, that facilities making medicated feed take steps to ensure adequate cleanout of their equipment in order to maintain proper drug levels and to avoid unsafe contamination of animal food with drugs. Flushing of equipment and sequential production of medicated feed are two commonly practiced procedures for preventing unsafe contamination from drug carryover. See Chapter 4, section 4.6.3 and 21 CFR 225.65.

Failure to perform proper equipment cleanout procedures or failure to adequately follow the procedures could result in contaminated animal food that may cause illness or death in animals. For example, incomplete cleanout from a previous batch of animal food manufactured with

monensin (which is particularly toxic to horses) has been the cause of contamination in animal food. In 2014 and 2015, monensin contamination of animal food resulted in the deaths of horses and layer hens (Refs. 76 and 77).

When conducting your hazard analysis, you should identify whether an animal drug used in your facility is a known or reasonably foreseeable hazard to another species, production class (e.g., layers versus broilers), or life stage (e.g., calf versus adult dairy cow) for which you manufacture animal food. If you identify a carryover drug hazard, you must evaluate it to determine if the carryover drug hazard requires a preventive control (see 21 CFR 507.33). If you determine a carryover drug hazard requires a preventive control, your preventive control might include physical cleanout of the equipment or sequencing of animal food production and flushing of equipment. You should also consider whether further preventive controls are needed to prevent the accidental addition of animal drugs to the wrong animal food that could result in unsafe animal food.

Nutrient deficiencies or toxicities as chemical hazards

Nutrient deficiency or toxicity hazards are a concern in animal food because animals often consume one animal food type as their sole source of nutrition. A nutrient deficiency or toxicity hazard can result in serious injury, illness, or even death to animals. A nutrient deficiency hazard can occur when a nutrient in the animal food is below the level needed by the intended animal and could result in illness or death (e.g., low thiamine in cat food that can result in neurological and other symptoms in cats). A nutrient toxicity hazard can occur when an excessive level of a nutrient is in animal food and could result in illness or death of the intended animal (e.g., excess sodium in poultry food that can result in trouble breathing, leg paralysis, and death). Because different animal species have different nutritional needs, certain quantities of a nutrient that are needed by one species of animal could pose a health risk to another species of animal.

A nutrient deficiency or toxicity hazard also can result from diets containing inappropriate proportions of essential nutrients. For example, the ratio of calcium and phosphorus should be considered when formulating an animal food since calcium and phosphorus work together for the animal's muscle and metabolic functions and are the major mineral constituents of bone.

There have been numerous animal food recalls as well as animal illnesses and deaths from nutrient deficiencies or toxicities. FDA has received multiple reports through its reportable food registry (RFR) that were a result of animal food with nutrient deficiencies or toxicities (Ref. 78). Examples of RFR reports and recalls include:

- low levels of thiamine in cat food
- low levels of vitamin D in food for swine
- elevated levels of copper in food for sheep
- elevated levels of vitamin D in dog, guinea pig, and fish food
- elevated levels of calcium and phosphorus in food for broiler chickens and turkeys

- elevated levels of urea in food for cattle

Nutrient deficiency or toxicity hazards can be the result of incorrect levels of nutrients in incoming raw materials or ingredients, incorrect recipe/formulation, errors in manufacturing, or a combination of these. If the raw materials or other ingredients do not contain nutrients at the expected levels, this may result in either a nutrient deficiency or toxicity hazard when the ingredient is incorporated into the animal food based on a preset formulation. For information on control strategies for nutrient deficiency or toxicity hazards, see Chapter 4, section 4.6.1.

Animal food distributed as a sole source of nutrition should be formulated to meet the minimum nutrient requirements established by the National Research Council (NRC) when available for the intended species (including life-stage and production class) (Ref. 79). Information in the peer-reviewed scientific literature, including NRC publications, also may be used to identify the maximum inclusion rate of certain nutrients. The NRC Mineral Tolerances of Animals also may be used to identify appropriate levels of minerals in animal food (Refs. 26 and 37). Another helpful resource for formulating a nutritionally adequate pet food is the AAFCO dog and cat food nutrient profiles (Ref. 36).

3.4.3 Facility-Related Chemical Hazards

Industrial chemicals or other contaminants from the animal food processing environment can contaminate animal food during production – e.g., if chemicals used to clean a production line are not adequately removed from the production line, if heavy metals are leaching from containers or utensils, or if a non-food-grade lubricant comes in contact with animal food. In this guidance, we do not discuss preventive controls for facility-related chemical hazards such as cleaning chemicals and the leaching of heavy metals from containers or utensils, because such hazards are usually addressed through CGMPs (see our GFI #235 entitled "Current Good Manufacturing Practice Requirements for Food for Animals").[16]

3.5 Physical Hazards

Physical hazards are broadly classified as sharp hazards, choking hazards, and conditions of animal food hazards such as size and hardness. Injuries from physical hazards may include oral cavity damage (e.g., tooth damage or laceration of the mouth or throat), laceration or perforation of the gastrointestinal tract, and choking. In this section, we describe common physical hazards – i.e., metal, glass, hard plastic, and conditions of animal food.

Metal (Ferrous and Non-Ferrous): Metal-to-metal contact during processing can introduce metal fragments into products. For example, metal fragments can break off during mechanical cutting and blending operations, and some metal equipment has parts that can break or fall off, such as wire-mesh belts. Metal screens may become worn over time or be torn, introducing metal fragments (Ref. 80).

Glass: Glass fragments in animal food can cause injury to the animal eating the food. Most animal food facilities do not use glass containers for their animal food, but fragments may be

[16] https://www.fda.gov/media/97464/download

introduced through the environment (e.g., overhead light fixtures made of glass that can fracture) or through ingredients that are contaminated with glass.

Hard Plastic: Hard plastic can be introduced into animal food when tools and equipment such as scoops, paddles, buckets, or other containers develop fatigue, crack, and break as they wear. Hard plastic also can be introduced into animal food when plastic sieves and screens deteriorate.

Conditions of Animal Food: The term "conditions of animal food" as used in this guidance refers to the physical, mechanical, and other characteristics (e.g., particle size, hardness, surface roughness, digestibility, and ability to soften when moistened) of animal food that can cause injuries or illness in animals. Hazards related to the conditions of the animal food can occur when the particle size is too large to eat resulting in starvation (e.g., crumbles too large for small birds). Alternatively, an animal food ground too fine can aerosolize and cause respiratory problems and corneal injuries, which occurred with swine food (Ref. 81). In addition, animal food ground too fine, or animal food that contains a large portion of fines (i.e., very small particles from the milling or pelleting process), can result in rapid fermentation by gut micro flora resulting in bloat in ruminants (e.g., cattle) (Refs. 82 and 83). Lack of digestibility can result in an obstructed digestive tract. An animal food could have a combination of characteristics resulting in injury or death (e.g., some dental treats for dogs) (Ref. 84).

In general, there is overlap between facility-related physical hazards and process-related physical hazards. For example, nuts and bolts used during maintenance procedures could be a facility-related hazard, but production equipment that has nuts and bolts that could fall out during production could be a process-related hazard. Conditions of animal food hazards are typically process-related hazards. Table 3-7 is a Quick Reference Guide to help you recognize some sources of these physical hazards.

Table 3-7. Quick Reference Guide for Some Sources of Physical Hazards

Source	Metal	Plastic, Ceramic, and Glass	Conditions of Animal Food	Other
Ingredient-related	Farm field debris Chopped, ground, and pulverized items where metal was not properly controlled by supplier	Farm field debris Packaging materials	Out of specification raw materials (e.g., too finely ground)	Farm field debris (e.g., stones, wooden sticks)
Facility-related and process-related (processing/ production environment and equipment)	Grinders, hammer-mills, shredders Sieves, screens, wire-mesh belts Mixing paddles Metal cans (shavings, lids) Pumps Utensils (knives)	Equipment (inspection belts, small wares) Facility (windows, air flow curtains) Facility glass Scoops Mixing paddles Buckets	Particle size of animal food inappropriate for animal species/life-stage Lack of digestibility	

3.6 References for Chapter 3

1. KuKanich, K. S. 2011. "Update on *Salmonella* spp. Contamination of Pet Food, Treats, and Nutritional Products and Safe Feeding Recommendations". *Journal of the American Veterinary Medical Association* 238 (11): 1430-1434. DOI: 10.2460/javma.238.11.1430.

2. Lambertini, E., Buchanan, R.L., Narrod, C., and A.K. Pradhan. 2016. "Transmission of Bacterial Zoonotic Pathogens between Pets and Humans: The Role of Pet Food". Critical Reviews in Food Science and Nutrition 56 (3): 364-418.

3. Centers for Disease Control and Prevention. Morbidity and Mortality Weekly Report, November 7, 2008. Accessed July 15, 2021. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5744a2.htm

4. Centers for Disease Control and Prevention. 2012. "Multistate Outbreak of Human *Salmonella* Infantis Infections Linked to Dry Dog Food (Final Update)". Accessed June 2, 2022. https://www.cdc.gov/salmonella/dogfood-05-12/index.html

5. Centers for Disease Control and Prevention. 2019. "Outbreak of Multidrug-Resistant Salmonella Infections Linked to Contact with Pig Ear Pet Treats (Final Update)". Accessed June 2, 2022. https://www.cdc.gov/salmonella/pet-treats-07-19/index.html

6. Hoelzer, K., *et al*. 2011. "Animal Contact as a Source of Human Non-Typhoidal Salmonellosis". *Veterinary Research* 42 (1): 34-34. DOI: 10.1186/1297-9716-42-34.

7. Sato, Y., *et al*. 2000. "*Salmonella virchow* Infection in an Infant Transmitted by Household Dogs". *Journal of Veterinary Medical Science* 62 (7): 767-769. DOI: 10.1292/jvms.62.767.

8. Morse, E. V., *et al*. 1976. "Canine salmonellosis: A review and report of dog to child transmission of *Salmonella* enteritidis". *American Journal of Public Health* 66 (1): 82-83.

9. Food and Drug Administration. 2015. "Carnivore Meat Company, LLC Voluntarily Issues a Recall Two Batches of Raw Pet Treats". Accessed July 15, 2021. https://wayback.archive-it.org/7993/20170112072755/http://www.fda.gov/Safety/Recalls/ArchiveRecalls/2015/ucm454400.htm

10. Food and Drug Administration. 2016. "Big Dog Natural Recalls Chicken and Fish Supreme Dog Food Due to Possible *Salmonella* and *Listeria monocytogene*s Health Risk". Accessed July 15, 2021. https://wayback.archive-it.org/7993/20180126102740/https://www.fda.gov/Safety/Recalls/ucm479873.htm

11. Food and Drug Administration. 2017. "Blue Ridge Beef Recalls Product Because of Possible Health Risk". Accessed July 15, 2021. https://www.fda.gov/safety/recalls/ucm537165.htm

12. Nemser, S. M., *et al*. 2014. "Investigation of *Listeria*, *Salmonella*, and toxigenic *Escherichia coli* in Various Pet Foods". *Foodborne Pathogen Disease* 11 (9): 706-709. DOI: 10.1089/fpd.2014.1748.

13. Stämpfli, H. R. 2021. "Botulism". In *Merck Veterinary Manual*. Accessed June 2, 2022. http://www.merckvetmanual.com/generalized-conditions/clostridial-diseases/botulism

14. The Center for Food Security and Public Health. 2018. "Botulism". Accessed July 15, 2021. http://www.cfsph.iastate.edu/Factsheets/pdfs/botulism.pdf

15. Myllykoski, J., *et al*. 2011. "Fur Animal Botulism Hazard Due to Feed". *Research in Veterinary Science* 90 (3): 412-418. DOI: 10.1016/j.rvsc.2010.06.024.

16. Food and Drug Administration. 2018. "OC Raw Dog, LLC Recalls Freeze Dried Sardines Because Product Exceeds FDA Size Restrictions." Accessed July 16, 2021.

https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts/oc-raw-dog-llc-recalls-freeze-dried-sardines-because-product-exceeds-fda-size-restrictions

17. Food and Drug Administration. 2020. "IcelandicPlus LLC Voluntarily Recalls Whole Capelin Fish Pet Treats Because Product Exceeds FDA Size Restrictions." Accessed July 16, 2021. https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts/icelandicplus-llc-voluntarily-recalls-whole-capelin-fish-pet-treats-because-product-exceeds-fda-size

18. The Center for Food Security and Public Health. 2017. "Toxoplasmosis". Accessed July 15, 2021. http://www.cfsph.iastate.edu/Factsheets/pdfs/toxoplasmosis.pdf

19. Guo, M., *et al*. 2015. "Prevalence and Risk Factors for *Toxoplasma gondii* Infection in Meat Animals and Meat Products Destined for Human Consumption". *Journal of Food Protection* 78 (2): 457-476. DOI: 10.4315/0362-028x.jfp-14-328.

20. Freeman, L. M, *et al*. 2013. "Current Knowledge about the Risks and Benefits of Raw Meat–Based Diets for Dogs and Cats". *Journal of the American Veterinary Medical Association* 243 (11): 1549-1558. DOI: 10.2460/javma.243.11.1549.

21. Jones, F. T. 2011. "A Review of Practical *Salmonella* Control Measures in Animal Feed". *The Journal of Applied Poultry Research* 20 (1): 102-113. DOI: 10.3382/japr.2010-00281.

22. Scott, V. N., *et al*. 2009. "Control of *Salmonella* in Low-Moisture foods I: Minimizing Entry of *Salmonella* into a Processing Facility". *Food Protection Trends* 29 (6): 342-353.

23. International Commission on Microbiological Specifications for Foods. 2005. "Cereals and cereal products Section IV; Flour, starches, and meals; Nuts, oilseeds, and dried legumes Section VI; Legume products". In *Microorganisms in Foods 6: Microbial Ecology of Food Commodities,* 409-413 and 460-46. New York, NY: Kluwer Academic/Plenum Publishers.

24. Codex Alimentarius International Food Standards. 2015, amended 2018. "Code of Hygienic Practice for Low-Moisture Foods". Accessed July 16, 2021. http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXC%2B75-2015%252FCXC_075e.pdf

25. Zink, D. 2007. "The Return of *Salmonella*: IAFP Special Interest Session on *Salmonella* Growth, Persistence and Survival in Low-Moisture Foods and their Environment - Strategies for Control". International Association of Food Protection Annual Meeting. Buena Vista, FL.

26. National Research Council of the National Academies. 2005. "Mineral Tolerance of Animals". In *The Mineral Tolerance of Animals,* Washington, DC: National Academies Press.

27. Blakley, B. R. 2021. "Copper Poisoning in Animals". In *Merck Veterinary Manual*. Accessed July 19, 2021. https://www.merckvetmanual.com/toxicology/copper-poisoning/copper-poisoning-in-animals?redirectid=1449

28. United States Environmental Protection Agency. 2017. "Setting Tolerances for Pesticide Residues in Foods". Accessed July 16, 2021. https://www.epa.gov/pesticide-tolerances/setting-tolerances-pesticide-residues-foods

29. Food and Drug Administration. 2009. Memorandum of Understanding with USDA (FSIS and AMS) and EPA regarding regulatory activities concerning residues of drugs, pesticides, and environmental contaminants in foods. (MOU 225-85-8400). Accessed July 19, 2021. https://www.fda.gov/AboutFDA/PartnershipsCollaborations/MemorandaofUnderstandingMOUs/DomesticMOUs/ucm116368.htm

30. Tchounwou, P. B., *et al*. 2012. "Heavy Metals Toxicity and the Environment". *Experientia Supplementum* 101 133-164. DOI: 10.1007/978-3-7643-8340-4_6.

31. Luippold, A., and M. S. Gustin. 2016. "Mercury Concentrations in Wet and Dry Cat and Dog Food". *Animal Feed Science and Technology* 222 (Supplement C): 190-193. DOI: 10.1016/j.anifeedsci.2016.10.021.

32. Li, Y., *et al*. 2005. "A Survey of Selected Heavy Metal Concentrations in Wisconsin Dairy Feeds". *Journal of Dairy Science* 88 (8): 2911-2922.

33. López-Alonso, M. 2012. "Trace Minerals and Livestock: Not Too Much Not Too Little". *International Scholarly Research Notices Veterinary Science* 2012 (Article ID 704825): 1-18. DOI: 10.5402/2012/704825.

34. Food and Agriculture Organization Animal Production and Health. 2010. "Health Hazards associated with Animal Feed". In *Good Practices for the Feed Industry* Accessed July 19, 2021. http://www.fao.org/docrep/012/i1379e/i1379e01.pdf

35. Blakley, B.R. 2021. "Lead Poisoning in Animals". In *Merck Veterinary Manual*. Accessed July 19, 2021. https://www.merckvetmanual.com/toxicology/lead-poisoning/lead-poisoning-in-animals

36. Association of American Feed Control Officials, Champaign, IL 61820. "The Association of American Feed Control Officials 2022 Official Publication". Accessed June 2, 2022. https://www.aafco.org/publications

37. National Research Council of the National Academies. 1980. "Mineral Tolerance of Domestic Animals". In *The Mineral Tolerance of Animals,* Washington, DC: The National Academies Press.

38. Bullerman, L. B., and A. Bianchini. 2007. "Stability of mycotoxins during food processing". *International Journal of Food Microbiology* 119 (1): 140-146. DOI: Accessed July 19, 2021. https://doi.org/10.1016/j.ijfoodmicro.2007.07.035

39. Rumbeiha, W., and J. Morrison. 2011. "A Review of Class I and Class II Pet Food Recalls Involving Chemical Contaminants from 1996 to 2008". *Journal of Medical Toxicology* 7 (1): 60-66. DOI: 10.1007/s13181-010-0123-5.

40. Food and Drug Administration. 2005. "FDA Issues Consumer Alert on Contaminated Pet Food". Accessed July 19, 2021. https://wayback.archive-it.org/7993/20161023022429/http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/2005/ucm108547.htm

41. Food and Drug Administration. 2011. Cargill Animal Nutrition Recalls River Run and Marksman Dry Dog Food". Accessed July 19, 2021. http://web.archive.org/web/20111208162340mp_/http://www.fda.gov/Safety/Recalls/ucm282753.htm

42. Food and Drug Administration. 2013. "Hy-Vee Issues Voluntary Recall of Certain Dog Food Products-Routine Testing Identifies Higher-Than-Normal Contaminant Levels in Select Products". Accessed July 21, 2021. https://web.archive.org/web/20161026111320/http://www.fda.gov/Safety/Recalls/ucm340891.htm?source=govdelivery

43. Food and Drug Administration. 2020. "Sunshine Mills, Inc. Issues Voluntary Recall of Certain Dog Food Products Due to Potentially Elevated Levels of Aflatoxin". Accessed July 19, 2021. https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts/sunshine-mills-inc-issues-voluntary-recall-certain-dog-food-products-due-potentially-elevated-levels

44. Food and Drug Administration. 2021. "Midwestern Pet Foods Voluntarily Expands Recall of Pet Food for Aflatoxin Health Risk". Accessed July 19, 2021. https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts/midwestern-pet-foods-voluntarily-expands-recall-pet-food-aflatoxin-health-risk

45. "Antinutrient". *Merriam-Webster Online.* Merriam-Webster. Accessed July 19, 2021. https://www.merriam-webster.com/medical/antinutrient

46. Food and Drug Administration. 1992. "Statement of Policy – Foods Derived from New Plant Varieties". Accessed July 19, 2021. https://www.fda.gov/regulatory-

information/search-fda-guidance-documents/statement-policy-foods-derived-new-plant-varieties

47. Tripathi, M. K., and A. S. Mishra. 2007. "Glucosinolates in Animal Nutrition: A Review". *Animal Feed Science and Technology* 132 (1): 1-27. DOI: 10.1016/j.anifeedsci.2006.03.003.

48. Hedberg, C. W., *et al*. 1987. "An Outbreak of Thyrotoxicosis Caused by the Consumption of Bovine Thyroid Gland in Ground Beef". *The New England Journal of Medicine* 316 (16): 993-998.

49. United States Department of Agriculture and Food Safety and Inspection Service. 1998. "Disposition of Livestock Thyroid Glands and Laryngeal Muscle Tissue". *Federal Register*, November 15, 1988, 53 FR 45888.

50. Broome, M. R., *et al*. 2014. "Exogenous Thyrotoxicosis in Dogs Attributable to Consumption of All-Meat Commercial Dog Food or Treats Containing Excessive Thyroid Hormone: 14 Cases (2008–2013)". *Journal of the American Veterinary Medical Association* 246 (1): 105-111. DOI: 10.2460/javma.246.1.105.

51. Food and Drug Administration. 2017. "Blue Buffalo Voluntarily Recalls One Lot of BLUE Wilderness® Rocky Mountain Recipe TM Red Meat Dinner Wet Food for Adult Dogs Due to Potential Health Risk". Accessed April 22, 2022. https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts/blue-buffalo-voluntarily-recalls-one-lot-blue-wildernessr-rocky-mountain-recipe-tm-red-meat-dinner?source=govdelivery

52. Food and Drug Administration. 2017. "Wellpet Voluntarily Recalls a Limited Amount of One Recipe of Canned Topper for Dogs Due to Potential Elevated Levels of Naturally Occurring Beef Thyroid Hormone". Accessed April 22, 2022. https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts/wellpet-voluntarily-recalls-limited-amount-one-recipe-canned-topper-dogs-due-potential-elevated

53. New Zealand Food Safety Authority. 2018. "Chapter 3: Supply, Slaughter and Dressing of Farmed Animals". In *New Zealand Food Safety Authority Code of Practice for Petfood Processing*. Accessed July 19, 2021. https://www.mpi.govt.nz/dmsdocument/23965-operational-code-petfood-processing

54. Food and Drug Administration. 2017. "Exogenous Hyperthyroidism and Thyroid Hormones in Pet Food – Veterinarians". Accessed July 19, 2021. https://wayback.archive-it.org/7993/20201222185753/https://www.fda.gov/animal-veterinary/product-safety-information/exogenous-hyperthyroidism-and-thyroid-hormones-pet-food-veterinarians

55. Food and Drug Administration. 2017. "Thyroid Hormones in Pet Food – Pet Food Industry". Accessed July 19, 2021. https://wayback.archive-

it.org/7993/20170404184730/https://www.fda.gov/AnimalVeterinary/ResourcesforYou/ucm548914.htm

56. Markus, C. K., *et al*. 1989. "Pet Food-Derived Penicillin Residue as a Potential Cause of Hypersensitivity Myocarditis and Sudden Death". *The America Journal of Cardiology*. 63 1154-1156.

57. Food and Drug Administration. 2013. "Milo's Kitchen® Voluntarily Recalls Chicken Jerky and Chicken Grillers Homestyle Dog Treats". Accessed July 19, 2021. http://wayback.archive-it.org/7993/20161023032825/http://www.fda.gov/Safety/Recalls/ArchiveRecalls/2013/ucm335621.htm

58. Food and Drug Administration. 2016, updated 2020, 2022. "Import Alert 72-07. Detention Without Physical Examination of Poultry Jerky-Type Pet Treats due to the Presence of Antibiotic and/or Antiviral Residue(s)". Accessed June 2, 2022. https://www.accessdata.fda.gov/cms_ia/importalert_1140.html

59. Peschka, M., *et al*. 2006. "Occurrence and Fate of Barbiturates in the Aquatic Environment". *Environmental Science & Technology* 40 (23): 7200-7206. DOI: 10.1021/es052567r.

60. O'Connor, J. J., *et al*. 1985. "Fate of Sodium Pentobarbital in Rendered Products". *American Journal of Veterinary Research* 46 (8): 1721-1724.

61. Kaiser, A. M., *et al*. 2010. "Secondary Pentobarbital Poisoning in Two Dogs: A Cautionary Tale". *Journal of Veterinary Diagnostic Investigation* 22 (4): 632-634. DOI: 10.1177/104063871002200423.

62. Verster, A., *et al*. 1990. "Accidental Pentobarbital Poisoning in a Lioness". *Journal of the South African Veterinary Association* 61 (1): 37-38.

63. Jurczynski, K., and E. Zittlau. 2007. "Pentobarbital Poisoning in Sumatran Tiger (Panthera Tigris Sumatrae)". *Journal of Zoo and Wildlife Medicine* 38 (4): 583-584. DOI: 10.1638/2006-0051R.1.

64. Corona, M. 2015. "Euthanized Horse Blamed for Contaminated Meat". In *Reno Gazette Journal*. Accessed July 19, 2021. http://www.rgj.com/story/news/2015/03/12/animal-ark-toxicology-results-shows-barbiturates-in-meat/70194788/

65. Food and Drug Administration. 2017. "Evanger's Voluntarily Recalls Hunk of Beef because of Pentobarbital Exposure in One Batch of Food". Accessed July 19, 2021. https://www.fda.gov/safety/recalls/ucm539900.htm

66. Food and Drug Administration. 2016. "Xylitol and Your Dog: Danger, Paws Off". Accessed July 19, 2021. https://www.fda.gov/consumers/consumer-updates/paws-xylitol-its-dangerous-dogs

67. Food and Drug Administration. 2017. "Melamine Pet Food Recall of 2007". Accessed April 22, 2022. https://www.fda.gov/animal-veterinary/recalls-withdrawals/melamine-pet-food-recall-2007

68. United States Department of Agriculture. 2007. "Interim Melamine and Analogues Safety/Risk Assessment". Washington, DC: United States Department of Agriculture.

69. Food and Drug Administration. 2008. "'Dear Colleague' Letter to the United States Food Manufacturing Industry, Regarding Melamine". Accessed July 19, 2021. https://wayback.archive-it.org/7993/20170111170320/http://www.fda.gov/Food/FoodborneIllnessContaminants/ChemicalContaminants/ucm164514.htm

70. The United States Pharmacopeial Convention. 2016. "Appendix XVII: Food Fraud Mitigation Guidance General Tests and Assays". In *Food Chemicals Codex*, 1586-1621.

71. Congressional Research Service. 2014. "Food Fraud and 'Economically Motivated Adulteration' of Food and Food Ingredients". Accessed July 19, 2021. https://fas.org/sgp/crs/misc/R43358.pdf

72. Ayotte, J. D., *et al*. 2007. "Occurrence of Uranium and ^{222}Radon in Glacial and Bedrock Aquifers in the Northern United States, 1993–2003". In *U.S. Geological Survey Scientific Investigations Report 2007-5037.* Accessed July 19, 2021. https://pubs.usgs.gov/sir/2007/5037/

73. Focazio, M. J., *et al*. 2001. "Occurrence of Selected Radionuclides in Ground Water Used for Drinking Water in the United States: A Reconnaissance Survey, 1998". In *U.S. Geological Survey Water-Resources Investigations Report 00-4273*. Accessed July 19, 2021. https://pubs.usgs.gov/wri/wri004273/pdf/wri004273.pdf

74. Food and Drug Administration. 2017. "Chemical Hazards". Accessed July 19, 2021. https://www.fda.gov/animal-veterinary/biological-chemical-and-physical-contaminants-animal-food/chemical-hazards#Industrial

75. United States Environmental Protection Agency. 2017. "Learn about Dioxin". Accessed July 19, 2021. https://www.epa.gov/dioxin/learn-about-dioxin

76. Food and Drug Administration. 2014. "Burkmann Feeds, Danville, KY Recalls 656-Layer Ration 20% Pellets Because of Possible Monensin Sodium Contamination". Accessed July 19, 2021. http://wayback.archive-it.org/7993/20170406075532/https://www.fda.gov/Safety/Recalls/ArchiveRecalls/2013/ucm428401.htm

77. Food and Drug Administration. 2015. "Western Milling LLC Voluntarily Recalls Western Blend Horse Feed, Lot 5251 Due To Potential Monensin Contamination". Accessed July 19, 2021. http://wayback.archive-it.org/7993/20170112071807/http://www.fda.gov/Safety/Recalls/ArchiveRecalls/2015/ucm464436.htm

78. Food and Drug Administration. 2016. "The Reportable Food Registry: A Five-Year Overview of Targeting Inspection Resources and Identifying Patterns of Adulteration". Accessed April 22, 2022. https://www.fda.gov/media/97862/download

79. National Academies of Sciences, Engineering, and Medicine. 2016. "Nutrient Requirement of Beef Cattle". In *Nutrient Requirements of Beef Cattle*, Washington, DC: The National Academies Press.

80. Food and Drug Administration. 2012. "Enforcement Report: Sirius Dog Treats". Accessed July 19, 2021. https://www.accessdata.fda.gov/scripts/ires/index.cfm?Product=112038.

81. Wondra, K. J., *et al*. 1995. "Effects of Particle Size and Pelleting on Growth Performance, Nutrient Digestibility, and Stomach Morphology in Finishing Pigs". *Journal of Animal Science*. 73 757-763.

82. Constable, Peter D. 2015. "Bloat in Ruminants". In *Merck Veterinary Manual*. Accessed July 19, 2021. https://www.merckvetmanual.com/digestive-system/diseases-of-the-ruminant-forestomach/bloat-in-ruminants

83. Rasby, Rick J., *et al*. 2010. "Bloat Prevention and Treatment in Cattle". University Of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Nebraska Extension Publications, G2018. Accessed July 19, 2021. https://extensionpublications.unl.edu/assets/html/g2018/build/g2018.htm

84. Leib, M. S., and L. L. Sartor. 2008. "Esophageal Foreign Body Obstruction Caused by a Dental Chew Treat in 31 Dogs (2000–2006)". *Journal of the American Veterinary Medical Association*. 232 (7): 1021-1025. DOI: 10.2460/javma.232.7.1021.

CHAPTER 4 – PREVENTIVE CONTROLS

4.1 Purpose of this Chapter

The guidance provided in this chapter is intended to help you identify and implement preventive controls for hazards you have determined require a preventive control. This chapter provides an overview of common preventive controls that you could use to significantly minimize or prevent the occurrence of biological, chemical, and physical hazards in animal food and the animal food production environment when the outcome of your hazard analysis is that one or more known or reasonably foreseeable hazards requires a preventive control. The guidance provided in this chapter also is intended to help you determine pertinent parameters to use when monitoring the preventive controls that you identify and implement.

This chapter does not provide all the details needed for identifying and implementing preventive controls. You have the flexibility to identify and implement preventive controls from among all procedures, practices, and processes that are available to you and that would provide assurances that the hazard is controlled (i.e., significantly minimized or prevented).

4.2 Overview of Preventive Controls

Preventive Controls

The Preventive Controls for Animal Food (PCAF) regulation defines "preventive controls" as those risk-based, reasonably appropriate procedures, practices, and processes that a person knowledgeable about the safe manufacturing, processing, packing, or holding of animal food would employ to significantly minimize or prevent the hazards identified under the hazard analysis that are consistent with the current scientific understanding of safe food manufacturing, processing, packing, or holding at the time of the analysis (21 CFR 507.3). Preventive controls include: (1) controls at critical control points (CCPs), if there are any CCPs; and (2) controls, other than those at CCPs, that are also appropriate for animal food safety (21 CFR 507.34(a)(2)(i) and (ii)).

The PCAF regulation requires that preventive controls must be written (21 CFR 507.34(b)). The PCAF regulation also specifies that preventive controls include, as appropriate to the facility and the animal food: (1) process controls; (2) sanitation controls; (3) supply-chain controls; (4) a recall plan; and (5) other preventive controls (see 21 CFR 507.34(c)). The PCAF regulation also requires you to validate that the preventive controls that you identify and implement are adequate to control the hazard as appropriate to the nature of the preventive control and its role in the facility's food safety system (see 21 CFR 507.47(a)), with some exceptions including sanitation controls in 21 CFR 507.34(c)(2) and the supply-chain program in subpart E of part 507 (see 21 CFR 507.47(c)). For information on validation and other preventive control management components, see Chapter 5.

4.3 Preventive Control Considerations

When identifying preventive controls for your animal food hazards, you should consider:

- The effect of the control on the targeted known or reasonably foreseeable animal food hazards. For example:
    - Is the preventive control hazard-specific or does it control more than one hazard?
    - Does the control effectiveness depend upon other controls?
    - Can the preventive control be validated (as necessary)?
    - Will the product be exposed to the environment following the preventive control?

- The feasibility of monitoring those controls. For example:
    - Are the minimum or maximum parameter values for the preventive control measurable and practical?
    - Are you relying on parameter values or observations for your monitoring?
    - Can you obtain the results of monitoring quickly (i.e., real-time) to determine if the process is in control?
    - Are you monitoring a batch or continuous process?
    - Are you monitoring continuously or doing spot checks?
    - Can the parameters be monitored in-line or must the animal food be sampled?
    - Will the monitored parameters be indirectly linked to the minimum or maximum values (i.e., belt speed or pump flow rate for time of process)?

- The location of the control with respect to other preventive control measures. For example:
    - Is the application of the control measure at the last point in the process to ensure control of the targeted known or reasonably foreseeable hazard?
    - Will the failure of an upstream control result in the failure of a downstream control(s)?

- Synergistic effects between control measures. For example:
    - Consider whether one control measure can enhance the efficacy of another control measure, e.g., formulation process controls may combine the use of preservatives, acidification, and a_w at levels that individually will not control pathogen growth, but they work together to do so.

4.4 Process Controls

Process controls include procedures, practices, and processes to ensure the control of parameters during operations such as heat processing, irradiating, and refrigerating animal food. Process

controls must include, as appropriate to the nature of the applicable control and its role in the facility's food safety system: (1) parameters associated with the control of the hazard; and (2) the maximum or minimum value, or combination of values, to which any biological, chemical, or physical parameter must be controlled to significantly minimize or prevent a hazard requiring a process control. See 21 CFR 507.34(c)(1). Process controls do not include those procedures, practices, and processes that are not applied to the animal food itself, e.g., controls of personnel or the environment that may be used to significantly minimize or prevent hazards.

4.4.1 Use of Parameter Values and Operating Limits in Process Controls

Parameters are those properties that are controlled to ensure the hazard will be significantly minimized or prevented and the parameter value is the maximum or minimum value, or combination of values, to which any biological, chemical, or physical parameter must be controlled to significantly minimize or prevent a hazard requiring a process control. Examples of process control parameters that can have a minimum or maximum parameter value (or combination of values) include time, temperature, flow rate, line speed, product bed depth, weight, product thickness or size, viscosity, moisture level, a_w, salt concentration, pH and others, depending upon the process. During processing, if a process control parameter value does not meet your identified minimum or maximum parameter value (or combination of values) in your food safety plan, the process is not in control (i.e., a deviation has occurred) and there is a potential for producing a product that presents a human or animal health risk.

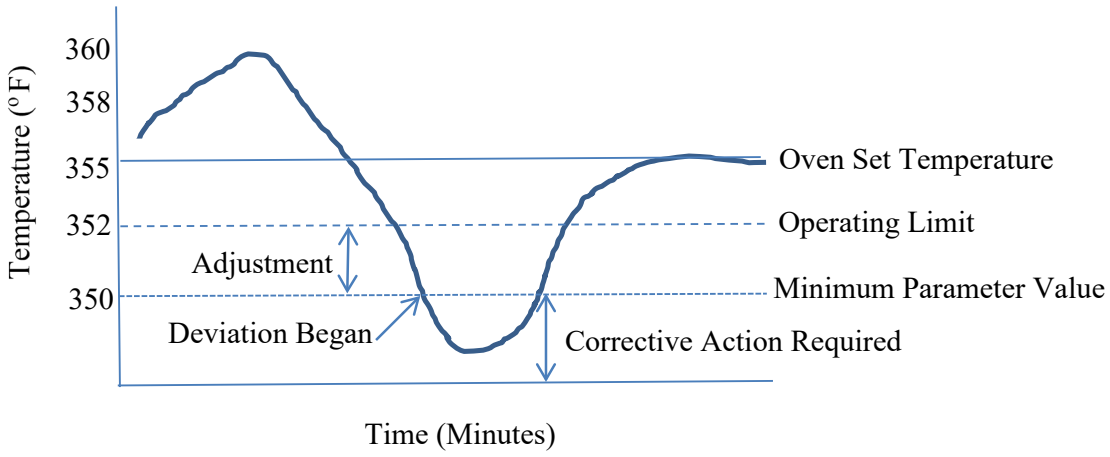
Operating limits are criteria that may be more stringent than your minimum or maximum parameter values of your preventive control and are established for reasons other than animal food safety. We recommend that you consider using operating limits to reduce the likelihood of a deviation from the established parameter value. Operating limits may be established to avoid deviations from an allowed parameter value, to account for normal variation, and for quality reasons. A benefit of using an operating limit is that such use may allow you to adjust your process if an operating limit is not met but the process does not deviate from your minimum or maximum parameter value. An additional benefit of using an operating limit is to account for quality parameters and for normal variability of production processes. Operating limits are not required under 21 CFR part 507 and we do not recommend you include them in your food safety plan (to avoid confusion with your required parameter values).

For example, you are baking dog biscuits and your minimum temperature parameter value established for controlling *Salmonella* is 350°F (177°C) and your minimum time parameter value is 15 minutes. In this example, we focus on the temperature parameter only and do not discuss time. Your written procedure would need to include both time and temperature if they are both parameters with values established for control of *Salmonella*. To achieve your desired quality specifications and to ensure safety, you bake the dog biscuits at 355°F (179°C) (i.e., the oven set temperature). If your minimum parameter value is 350°F (177°C) to control *Salmonella*, you may have an operating limit of 352°F (178°C). If you use an alarm system on your oven, you may set the alarm so if your oven temperature drops to 352°F (178°C), the alarm will sound and you can adjust the oven temperature to ensure that the temperature does not drop below the minimum parameter value of 350°F (177°C). However, if you are finding that the alarm is sounding often because your oven temperature drops below your operating limit, you should

consider taking additional steps to ensure a more consistent oven temperature. If the oven temperature drops below the minimum parameter value of 350°F (177°C), the hazard is not under control and a corrective action is required.

See Figure 4-1 for an illustration on the use of operating limits to avoid a deviation from an established parameter value and Chapter 5 (section 5.7) for a discussion about corrective actions. One source of additional information on the use of operating limits is the FSPCA curriculum (Ref. 1).

Figure 4-1: The use of operating limits to avoid a deviation from an established parameter value



4.5 Process Controls for Biological Hazards

Many process controls, such as the application of heat to an animal food to adequately reduce pathogens, are applied in the same manner and for the same purpose as control measures established within Hazard Analysis and Critical Control Point (HACCP) plans for human food and applied at CCPs as recommended by the National Advisory Committee on Microbiological Criteria for Foods (Ref. 2) and the Codex Alimentarius Commission (Ref. 3). No HACCP system has been mandated by FDA for any animal food. HACCP principles have been voluntarily adopted by some segments of the animal food industry, such as some in the rendering industry and pet food industry.

In addition to this guidance, a number of sources of scientific and technical information can be useful in establishing process control parameters and parameter values. These sources may use the term "critical limit" as opposed to parameter value. While these terms have a similar meaning, critical limit is more closely associated with HACCP. Trade associations, process authorities, industry scientists, university and extension scientists, and consultants can be a resource for establishing process control parameters and parameter values. The Consumer Brands Association, formerly known as the Grocery Manufacturers Association, has provided advice on control of *Salmonella* in low-moisture foods (Ref. 4), and the American Feed Industry Association has provided advice on control of *Salmonella* in animal food (Ref. 5). Information also can be obtained from peer reviewed scientific literature. For additional resources, see the training materials provided by the Food Safety Preventive Controls Alliance for human food and

animal food (Refs. 1 and 6). In addition to information from such resources, you also can conduct scientific studies for specific products in-house, at a contract laboratory, or at a university to establish appropriate process control parameters and parameter values.

Note that there may be differences between the application of process control parameters as discussed in these referenced sources and how you would apply the process control parameters to your specific animal food and manufacturing process. For example, your animal food matrix may have a different particle size or composition than the reference source. The process control parameters and/or minimum or maximum parameter values may need to be adjusted to account for those differences. The process control parameter and parameter value(s) must be validated in accordance with 21 CFR 507.47. For more information on validation see Chapter 5, section 5.8.2.

4.5.1 Use of Lethality Treatments as Process Controls

The term "lethality treatment" refers to a treatment that is used to kill or inactivate microorganisms. In general, when discussing bacterial pathogens in this document we use the terms "kill" or "destroy" when referring to treatments lethal to vegetative cells and "inactivate" when discussing treatments lethal to spores. Protozoa may be killed or inactivated by common lethality treatments (Refs. 7, 8 and 9). Common lethality treatments include: (1) heat treatments (e.g., extrusion, cooking, pasteurizing, or baking); (2) high pressure processing (HPP); and (3) irradiation. We discuss each of these in the following sections of this chapter.

Heat treatment (thermal processing)

Heat treatment is a common lethality process control. Heat treatments generally fall into the following two categories:

- Heat treatment that leads to commercial sterility: heat processing at high temperatures (internal food temperature is > 212ºF (100°C)) under pressure with the objective of killing all forms of microorganisms, including the spores of bacteria. The treated products are shelf-stable without refrigeration.

- Heat treatment that reduces microbial pathogens but does not lead to commercial sterility: heat processing at lower temperatures (e.g., internal food temperature is 158°F (70°C) to 212°F (100°C)), with the objective of killing the vegetative forms of microorganisms with little to no effect on the spores of bacteria. The treated products may or may not be intended to be shelf-stable. Pelleting and extrusion are examples of heat treatment processes that kill vegetative microbial pathogens and the resulting products are shelf-stable. Pasteurization is an example of a heat treatment that reduces microbial pathogens but does not lead to a shelf-stable product. Pelleting, extrusion, and pasteurization are typically applied to kill non-sporeformers such as *Salmonella*, *L. monocytogenes*, and pathogenic strains of *E. coli*.

This chapter does not address heat treatments that lead to commercial sterility of low-acid canned foods. Such treatments are subject to the requirements of 21 CFR 500.23 and 21 CFR

part 113 (Thermally Processed Low-Acid Foods Packaged in Hermetically Sealed Containers; commonly called Low-Acid Canned Foods (LACF)). Microbiological hazards regulated under part 113 are not subject to the requirements for hazard analysis and risk-based preventive controls. Note that although some hermetically sealed containers (e.g., pouches or trays) used to package thermally processed low-acid foods generally would not be viewed as cans, the term "low-acid canned foods" has been used for decades as a shorthand description for thermally processed low-acid foods packaged in hermetically sealed containers, and we continue to use that term (and its abbreviation, LACF).

Thermal destruction of microorganisms

To design a lethal heat treatment for use as a preventive control, you should have a basic understanding of thermobacteriology (i.e., the relationship between bacteria and heat), including two key types of data and information:

1. The kinetics of thermal inactivation or destruction of microorganisms, known as thermal death time data; and,

2. The rate at which heating occurs within the animal food, also known as heat transfer or heat penetration.

Immediately following, we describe basic concepts associated with thermal death time data and heat transfer/heat penetration. A more extensive review of thermobacteriology, including graphical representations of the relationship of *D*-values and *z*-values to Thermal Death Time, is available (Ref. 10).

Some terms and concepts used to describe the thermal destruction of microorganisms include:

- ***F*-value or TDT (Thermal Death Time)** is the time required to kill a given population of microorganisms at a specified temperature

- ***D*-value or the decimal reduction time** is the time required to kill 90% of a population of microorganisms at a constant temperature and under specified conditions

- ***Z*-value** refers to the temperature increase required to reduce the *D*-value by a factor of 10

Food processing experts evaluate treatments intended to kill or inactivate pathogens in food in terms of logs of kill, where the term "log" is a shorthand expression of the mathematical term logarithm. A logarithm is the exponent to which a base number must be raised to equal a given number. In thermobacteriology, the base number is usually 10. As an example, the number 100 = 10^2 where the base number is 10 and the exponent is 2. Because the exponent is 2, a 2-log reduction represents a 100-fold reduction. Likewise, a 3-log reduction represents a 1000-fold reduction, 10^3. The important thing to understand is that each log of kill is capable of causing a ten-fold reduction in the population of microorganisms that the treatment is designed to kill, i.e., the most resistant microorganism of public health significance.

The decimal reduction time (*D*) is used synonymously with log in the context of thermobacteriology. A 1-log or 1-*D* process would be one that is capable of reducing the population of the most resistant microorganism of concern in the animal food ten-fold, e.g., from 10,000 cells of the microorganism per gram of animal food to 1,000 cells of the microorganism per gram of animal food. Importantly, it is not possible for a process to technically achieve a level of reduction equivalent to zero, or no microorganisms in animal food; instead, as a technical matter the probability of finding the organism becomes less likely as the number of log reduction increases. Thus, a 5-log reduction process would be one that is capable of reducing the population by 100,000 fold, e.g., from 10,000 cells of the microorganism per gram of animal food to a probability of 1 cell in 10 grams of animal food, or 100,000 cells of the microorganism per gram of animal food to a probability of 1 cell per gram of animal food. You should use a heat treatment that delivers a sufficient amount of log reduction to ensure the most resistant microorganism of concern is non-detectable when the animal food is tested using a validated method.

Table 4-1 provides examples of the effect of lethal heat treatments on microorganisms in animal food using terms commonly associated with thermobacteriology.

Table 4-1. The Concept of Log Reductions of Microorganisms in Animal Food

Initial Number of the Most Resistant Microorganism of Concern Per Gram of Animal Food	Log Reduction (also known as *D*)	Decrease in Most Resistant Microorganism of Concern Per Gram of Animal Food	Percent of Change	Final Number of Most Resistent Microorganism of Concern Per Gram of Animal Food
10,000 or 4 log [1]	1	10-fold	90%	1,000 or 3 log
10,000 or 4 log	2	10 X 10 = 100-fold	99%	100 or 2 log
10,000 or 4 log	3	10 X 10 X 10 = 1000-fold	99.9%	10 or 1 log
10,000 or 4 log	4	10 X 10 X 10 X 10 = 10,000-fold	99.99%	1 or 0 log
10,000 or 4 log	5	10 X 10 X 10 X 10 X 10 = 100,000-fold	99.999%	0.1 or -1 log [2]
10,000 or 4 log	6	10 X 10 X 10 X 10 X 10 = 1,000,000-fold	99.9999%	0.01 or -2 log

[1] Additional equivalent ways to express 10,000 include 10^4, 10^4, and 10E4.

[2] Additional equivalent ways to express 0.1 include 10^{-1} or 1 in 10.

Relative heat resistance of microorganisms

Some microorganisms are more resistant to heat than other microorganisms and, thus, require more stringent heating conditions to kill or inactivate them. Table 4-2 shows the relative heat resistance of common types of microorganisms.

Table 4-2. Relative Heat Resistance of Microbial Forms

Resistance to Heat	Microbial Form
Highest	Bacterial Spores
Moderate	Some vegetative bacterial cells Cysts of parasites Fungi, including fungal spores
Least	Some vegetative bacterial cells Viruses

As already noted, this chapter addresses heat treatments that reduce pathogens in animal food but do not lead to commercial sterility. These heat treatments are used to significantly minimize the number of vegetative cells of bacterial pathogens such as *Salmonella*, *L. monocytogenes*, and pathogenic *E. coli*.

Factors affecting the heat resistance of microorganisms

In addition to the inherent heat resistance of specific microorganisms (or life stages of microorganisms, such as the spore stage) other factors associated with animal food (such as a_w, fat content, salt content, pH, and protein content) can affect the heat resistance of microorganisms. Table 4-3 lists the most common factors that you should consider when designing a heat treatment as a process control for biological hazards.

Table 4-3. Factors that Influence the Heat Resistance of Microorganisms in Animal Food

Factor	Effect on Microbial Heat Resistance
Water	As the a_w, humidity, or moisture goes down, in general the heat resistance increases.
Fat	As the fat content increases, there is a general increase in heat resistance of some microorganisms.

Factor	Effect on Microbial Heat Resistance
Salts	The effect of salt varies and depends on the kind of salt and its concentration. Some salts that decrease a_w appear to increase heat resistance of microorganisms while other salts that may increase a_w (e.g., calcium and magnesium) appear to decrease heat resistance.
Carbohydrates	The presence of sugars can increase the heat resistance of microorganisms due in part to the decrease in a_w.
pH	Most microorganisms are more heat resistant near their optimum pH for growth. Generally, as the pH increases or decreases relative to this optimum pH, the microorganisms become more sensitive to heat.
Proteins	Proteins have a protective effect and, thus, increase the heat resistance of microorganisms.

Other factors that can influence the heat resistance of microorganisms include the number of microorganisms, the age of the microorganisms, the temperatures at which microbial growth occurs, the presence of inhibitory compounds, and the time-temperature combination used.

Lethal heat treatments

Lethal heat treatments (heat treatments) such as baking, rendering, roasting, pelleting, extrusion, and other conventional heating methods are used for processing a wide variety of animal food (e.g., cereal-grain products, pet food kibble, jerky treats, and fish food). Heat treatments may be performed for a variety of reasons, such as to make animal food safe by significantly minimizing (which includes eliminating) foodborne pathogens such as *Salmonella* and *L. monocytogenes*, to improve palatability, to increase nutrient bioavailability, and to inactivate anti-nutrient factors. This discussion focuses on the heat treatment methods for biological hazards and animal food safety.

There are a variety of ways to manage the application of these heat treatments depending upon the type of animal food and the method of heat application (e.g., rendering or extrusion). You may obtain information from peer-review journals and extension white papers to determine appropriate heat treatment parameters for your facility and type of animal food. Alternatively, you could establish the process scientifically and validate it through a scientific study demonstrating that if the minimum/maximum values are met for all the pertinent parameters (e.g., cooking temperature, time, and particle size) all particles will receive an adequate heat treatment. For example, the processing time and temperature to significantly minimize pathogens in a homogeneous mixture of an ingredient with uniform particle size and density may be different than an animal food containing different size and density particles of various ingredients. As another example, an all-dry kibble and a kibble with a semi-moist center would

be processed using different time-temperature combinations. Besides time and temperature, other factors may impact process effectiveness.

Normally, a study to validate a heat treatment is performed by a person or group knowledgeable in the design of heat treatments to determine the critical parameters required for the heat process being applied to ensure that it delivers the desired reduction level (logs of kill, as described earlier in this chapter). If you do a study to validate the adequacy of your heat treatment preventive control(s), a preventive controls qualified individual (PCQI) must conduct (or oversee) your study. See CFR 507.47(b)(1). You may choose to seek assistance for your study from entities with special expertise in heat treatments. Thus, for such studies, your PCQI will likely oversee, rather than conduct, the study. Once that study has been completed, the person conducting the study will provide a time and temperature for the processor to monitor during processing, as well as any other parameters that are critical to delivery of an adequate heat treatment, such as maximum particle size.

Emerging technologies based on thermal effects

Microwave, radio frequency, ohmic heating, and inductive heating are heat-based processes that can kill microorganisms by thermal effects. Microwave and radio frequency heating are based on the use of electromagnetic waves of certain frequencies to generate heat in a material through two mechanisms - dielectric and ionic. Ohmic heating is the process of passing electric currents (primarily alternating) through animal food to heat it. The heating occurs in the form of internal energy generation within the material. Ohmic heating is distinguished from other electrical heating methods by the presence of electrodes contacting the animal food (as opposed to microwave heating, where electrodes are absent), and depends on frequency of the current and waveform (typically sinusoidal). Inductive heating is a process of inducing electric currents within the animal food due to oscillating electromagnetic fields generated by electric coils.

For any of these heat-based processes, the cumulative lethality delivered by the process (as represented in a heating curve which measures total time the food is exposed to the rising and falling temperatures) and the location of the cold points will determine the effect on microorganisms. The effectiveness of these processes also depends on a_w and pH of the product. Although the shape of the destruction or inactivation curves is expected to be similar to those in conventional heating, the intricacies of each of the technologies need special attention if you plan to use them for microbial destruction or inactivation. For instance, in microwave heating a number of factors influence the location of the cold points, such as the composition, shape, and size of the food, the microwave frequency, and the applicator design. The location of the coldest-point and time/temperature history can be predicted through simulation software, and we expect that animal food manufacturers may be able to use these emerging technologies in the future.

Additional information about these and other heat treatment technologies is available (Refs. 11, 12, and 13).

High pressure processing (HPP)

Microorganisms vary in their sensitivity to high pressure. If you plan to use HPP, you should consider the target pathogen (e.g., *Salmonella, L. monocytogenes*, pathogenic *E. coli, C. botulinum*, and *T. gondii)*, animal food characteristics, and whether the process is to result in animal food that will be frozen, refrigerated, or shelf-stable. Destruction of the microorganism is primarily caused by changes in the structure and permeability of the cell wall, which causes fluids to be forced into the cell.

Bacterial spores are the most pressure-resistant biological forms known. Spores resist inactivation by high pressure alone and most require the addition of heat or some other mechanism to achieve appropriate levels of destruction. *C. botulinum* is one of the most pressure-resistant microorganisms (Ref. 10). Because of this, if *C. botulinum* is a known or reasonably foreseeable hazard in your animal food and the animal food is processed using HPP, you should refrigerate or freeze the animal food to provide control of sporeformers and toxin production.

The unit of measure frequently used for HPP in the food industry is the pascal (Pa) or megapascal (MPa, 1,000,000 Pa). High pressure processing of food requires pressures of 400 to 700 MPa, or 4000-7000 bars (58,000-101,000 pounds per square inch gauge). Most commercial human food industry applications use pressures in the range of 600 to 700 MPa (Ref. 10).

High pressure processing requires very specialized and costly equipment. Currently, the human and animal food industry uses HPP batch systems. For batch processing, the food is packaged in a flexible or semi-flexible package, prior to placing the product in the HPP system, where the product is placed into a chamber and immersed in water or some other pressurizing fluid, then subjected to the high pressure for a time of 1-20 minutes, depending on the temperature and pressure. The chamber is then depressurized, and the product removed. Applications and the feasibility for commercialization for other HPP systems such as semi-continuous, continuous, and pulsed HPP have been described elsewhere (Ref. 10).

The pressure-time combination sufficient to inactivate pathogens with the greatest resistance to inactivation by pressure is determined based on the estimated pathogen load (i.e., number of pathogens per gram of food) in the animal food. Detailed reviews of the application and use of HPP as a process control in human food are available (Refs. 10 and 14). Publicly available data on pressure ranges and corresponding retention times required for inactivating pathogens in animal food during HPP treatments are limited at this time. If you rely on HPP to control pathogens in your animal food, you will likely need to conduct studies to validate your pressure-time combinations for inactivating pathogens in that animal food (see 21 CFR 507.47).

Irradiation

Food is irradiated primarily to inactivate organisms that cause spoilage, quality deterioration, or are an animal food safety concern.

The application of ionizing radiation damages DNA and very effectively inhibits DNA synthesis and further cell division in organisms exposed to these forms and levels of energy. The amount of radiation energy used to control organisms varies according to the radiation resistance of the

particular organism, which is often specific to the number or load of the organisms present (Ref. 15).

In the United States, a source of radiation used to irradiate food is considered a food additive and, as such, the use of irradiation in producing food (including animal food) requires premarket approval by FDA. See sections 201(s) and 409 of the FD&C Act and 21 CFR part 579, which incorporates part 179 (21 CFR 579.12). The only sources of ionizing radiation approved for use on specific types of animal food are cobalt-60 or cesium-137 generated gamma rays, electron beams not exceeding 10 million electron volts (MeV), and X-rays not exceeding 5 MeV or 7.5 MeV (except as otherwise permitted) depending on the source. See 21 CFR 579.22 and 579.40.

Some common terms used when describing the application of ionizing radiation in the treatment of animal food are:

- Dose (absorbed) – The amount of energy absorbed per unit mass of irradiated material
- *D*-value – Amount of radiation required to reduce the population of a specific microorganism by 90% (1-log) under the stated conditions
- Gray (Gy) – A unit of absorbed dose of ionizing radiation, equal to 1 joule/kg of irradiated material (e.g., animal food)
- Electron volt (eV) – A unit of energy. One electron volt is the kinetic energy acquired by an electron in passing through a potential difference of one volt in a vacuum

Food treated with ionizing radiation must receive the minimum radiation dose reasonably required to accomplish its intended technical effect and not more than the maximum dose specified by the applicable regulation for that use. See 21 CFR 179.25(b). Table 4-5 summarizes maximum allowed doses of radiation for certain animal foods. Doses below 10 kiloGrays (kGy) have been used to inactivate pathogens such as *Salmonella* in dry cat, dog, and rodent food (Ref. 16). Irradiation of dried chicken-breast meat at 10-25 kGy was studied for use as pet food and the study authors concluded that the irradiated chicken meat was safe for that use (Ref. 17).

Table 4-4 provides a summary of compiled data on the ranges of decimal reduction doses (*D*-values) for some non-spore-forming pathogenic bacteria determined in various human foods under various conditions (Ref. 15). Only the pathogenic bacteria relevant to animal food are listed in the table. If you use irradiation to control bacterial pathogens in your animal food, you should base your irradiation doses on *D*-values determined for pathogens under similar conditions (e.g., composition, physical state, atmospheric environment, and temperature of the animal food).

Table 4-4. *D*-values (kGy) for Some Foodborne Pathogenic Bacteria

Bacteria	Non-frozen food	Frozen food
Salmonella spp.	0.18-0.92	0.37-1.28
L. monocytogenes	0.20-1.0	0.52-1.4
E. coli O157:H7	0.24-0.43	0.30-0.98

Bacterial spores are more resistant to irradiation than non-spore-forming bacteria. The spores of *C. botulinum* types A and B are particularly resistant.

For illustrative purposes, Table 4-5 lists the FDA-approved uses of ionizing radiation for animal food as of 2022. We created the table from the regulatory language in 21 CFR 579.22 and 579.40, which specifies the limitations on the approved uses of ionizing radiation for the treatment of animal food. You should refer to 21 CFR part 579 for the most current limitations on the approved uses for the treatment of animal food using ionizing radiation.

Table 4-5. FDA-Approved Uses for the Ionizing Radiation Treatment of Animal Food

Animal Food	Use	Dose	Limitations
Bagged complete diets, packaged feeds, feed ingredients, bulk feeds, animal treats and chews	Microbial disinfection, control or elimination	Not to exceed 50 kiloGrays (kGy)	Animal food and animal food ingredients treated by irradiation should be formulated to account for nutritional loss
Poultry feed and poultry feed ingredients	Single treatment for rendering complete poultry diets or poultry feed ingredients *Salmonella* negative	Minimum dose 2.0 kGy; maximum dose 25 kGy. The absorbed dose of irradiation is to be based on initial concentration of *Salmonella* using the relationship that 1.0 kGy reduces *Salmonella* concentration by one log cycle	For poultry feed or feed ingredients that do not contain drugs Feeds should be formulated to account for nutritional loss

See 21 CFR part 579, subpart B – Radiation and Radiation Sources.

The regulation includes requirements to account for nutritional loss after irradiation. This nutritional loss could result in a nutrient deficiency hazard that you determine requires a preventive control. In dry cat, dog, and rodent food, gamma radiation within the approved dose is known to cause a significant reduction in Vitamin A (Ref. 16). Irradiated cat food has been associated with the development of neurological disease in cats under certain circumstances (Ref. 18).

4.5.2 Use of Time and Low Temperature as Process Controls

Temperature is an essential factor that affects the growth of bacteria. Bacterial growth can occur over a wide range of temperatures from about 23°F (-5°C) to 194°F (90°C).

Thermophiles grow at temperatures above 131°F (55°C). Mesophiles (e.g., *Salmonella* spp. and *E. coli*) grow at or near room temperatures. Psychrophiles grow at or near refrigeration temperatures. Psychrotrophs (e.g., *L. monocytogenes*) are capable of growth at refrigeration temperatures, but their optimal growth temperature is in the mesophilic range. Table 4-6 lists four types of bacteria based on their temperature growth ranges.

Table 4-6. Temperature Ranges for the Growth of Microorganisms

Group	Minimum Temperature for Growth °F (°C)	Optimum Temperature for Growth °F (°C)	Maximum Temperature for Growth °F (°C)
Thermophiles	104 - 113 (40 - 45)	131 - 167 (55 - 75)	140 - 194 (60 - 90)
Mesophiles	41 - 59 (5 - 15)	86 - 113 (30 - 45)	95 - 117 (35 - 47)
Psychrophiles	23 - 41 (-5 - +5)	54 - 59 (12 - 15)	59 - 68 (15 - 20)
Psychrotrophs	23 - 41 (-5 - +5)	77 - 86 (25 - 30)	86 - 95 (30 - 35)

Typically, the higher the temperature (within the normal growth range), the more rapid the growth of the microorganism. It is not only the temperature that is of concern; it is the total time of exposure at temperatures that allows growth that needs to be minimized. The most general recommendation is to hold refrigerated food below 41°F (5°C).

Refrigeration

Refrigeration works well for controlling the growth of most pathogenic bacteria. However, some pathogens, like *L. monocytogenes* can grow at temperatures close to freezing. Refrigeration has the added advantage of slowing down biological and chemical processes that result in spoilage and oxidative rancidity.

Maintaining cold temperatures during storage can be accomplished in several ways, such as ice, chemical coolant gel packs, and mechanical dry refrigeration (e.g., in a cooler). You should ensure an adequate amount of ice or gel packs is present on the animal food at all times and monitor the temperature with a thermometer or temperature recording device.

For mechanical dry refrigerated storage in a cooler, if the ambient temperature can be related to the product temperature, monitoring the temperature of the storage area will ensure that the product temperature is maintained. Monitoring of the cooler is ordinarily done using continuous monitoring instruments such as recorder thermometer charts, maximum-indicating thermometers, and high temperature alarms.

Time/Temperature

When food that is intended to be stored under refrigeration is removed from refrigeration, the temperature of the food gradually increases and can reach the temperature associated with the growth range specific to particular pathogens. Bacterial pathogens go through a lag phase, where little or no growth occurs as the microorganisms adjust to their new environment. As the product temperature approaches the growth range, pathogens enter what is called the log phase where their numbers increase logarithmically. For animal food intended to be refrigerated, the objective is to prevent the log phase from happening, ideally keeping pathogens in their lag phase. We call the temperature range of concern (41°F (5°C) to 135°F (57°C)) the danger zone (Ref. 19). Different pathogens have different rates of growth at different temperatures, and the rate of growth will be affected by the type of animal food and its inherent properties. Therefore, the actual maximum time that an animal food may be safely held in the danger zone depends on a number of factors, including the type of pathogens that are present and the ability of the animal food to support their growth.

Management of time and temperature during processing may be more complicated than during storage, because it involves information about the time and temperature exposure of the animal food (including raw materials and ingredients) during production. You can manage time and temperature during processing in a variety of ways, such as marking units of animal food and tracking how long they remain at unrefrigerated temperatures; monitoring the temperature in a chilled processing room; or monitoring animal food temperatures during different phases of production.

Cooling after cooking

Cooling after cooking can be a critical function influencing the safety of human food (Ref. 19). Cooling after cooking may be important for animal food that is cooked but still requires refrigeration (e.g., pet food that is not shelf-stable). Depending upon the animal food type and raw materials and ingredients, cooked animal food can still have viable pathogenic bacteria present. Pathogens that are particularly heat tolerant (such as *L. monocytogenes* and the spores of *C. botulinum*) can sometimes survive the cooking process; however, this should not be the case if you selected the appropriate target pathogen for control by the applied process and you validated the control.

The spores of spore-forming pathogens (such as *C. botulinum*), if they are present, can survive the cooking process because temperatures that can only be achieved under pressure are usually needed to inactivate spores. These spores will begin to germinate when the product temperature drops to a temperature at which they can grow (usually below 135°F (57°C)). If the animal food is temperature-abused, pathogenic spores could germinate, grow, and the resulting cells can possibly produce toxin due to the fact that most spoilage bacteria (which may otherwise compete for growth) have been eliminated by the cooking process (Ref. 19).

If the cooking process is adequate (i.e., heat and pressure) to inactivate spores, the cooling step will not be critical. However, the animal food can be recontaminated during the cooling process as a result of improper handling, condensate or drip, or contact with other animal food.

Freezing

During frozen storage, populations of viable microorganisms in most animal food will decrease; however, some microorganisms remain viable for long periods of time during frozen storage. Most viruses, bacterial spores, and some bacterial cells survive freezing unchanged. Some other microorganisms (e.g., parasitic protozoa such as *T. gondii*), are generally more sensitive than viruses and bacteria to the freezing and thawing process (i.e., freezing, frozen storage, or thawing). For this reason, freezing and frozen storage are good methods for inactivating protozoa in various animal food (Ref. 7). This is especially important if animals are likely to eat the animal food raw, after thawing. However, freezing should not be considered a preventive control to significantly minimize pathogens such as *Salmonella* spp., *L. monocytogenes*, and pathogenic *E. coli*.

4.5.3 Use of Product Formulation as Process Controls

In this section of this chapter, we discuss two key factors, a_w and pH, that are frequently used as a formulation process control. We also discuss the use of preservatives as a formulation process control.

Water activity (a_w)

Microorganisms need water to survive as well as to grow. Two measurements relevant to safety of animal food are equilibrium relative humidity (ERH) and a_w. The a_w refers to the availability of water to the organism. In general, microorganisms survive and grow better when the a_w is high than when the a_w is low.

If you have a closed container of pure water, the air above the water becomes saturated with water vapor over time. The ERH of the air at saturation is 100%, which is equivalent to an a_w of the water of 1.0. Thus, pure water has an a_w of 1.0 (Ref. 20).

Animal food represents more complex systems than water, and the water can bind to components of the animal food so not all the water in the animal food is available to microorganisms; thus, the a_w of animal food is less than 1.0.

The a_w is directly related to the vapor pressure of the water in a solution. You can determine a_w by measuring the ERH of the air over the solution in a closed container. Equilibrium relative humidity, expressed as a percentage, divided by 100 equals the a_w:

$$a_w = ERH/100$$

or the partial pressure of water vapor above the animal food (p) divided by the partial pressure of water vapor above pure water (p_o) at the same temperature: (Ref. 21).

$$a_w = p/p_o$$

Animal food types vary in their a_w and can be classified into three categories based on a_w: moist animal food (a_w above 0.85), intermediate-moisture animal food (a_w between 0.60 and 0.85), and low-moisture animal food (a_w below 0.60). Depending on a_w, animal food may require additional preventive controls to significantly minimize pathogens. Moist animal food would require refrigeration or another control such as heat treatment, acid pH, or preservatives to control the growth of pathogens. Intermediate-moisture animal food would not require refrigeration to control pathogens but may have a limited shelf life because of spoilage, primarily by yeast and mold. The microbiological stability of intermediate-moisture animal food may depend on factors other than a_w, such as reduced pH, chemical preservatives, heat treatments, or combinations of these, even though the reduced a_w is of major importance. Low-moisture animal food has an extended shelf life, even without refrigeration when stored properly. Table 4-7 classifies animal food into three categories based on a_w and provides examples of animal food types.

Table 4-7. Examples of Animal Food Types Based on Water Activity (a_w)

Water Activity (a_w)	Categories	Animal Food Types
Above 0.85	Moist Animal Food	Refrigerated and frozen pet food Fresh meats and fish Fresh fruits and vegetables
Between 0.60 and 0.85	Intermediate-Moisture Animal Food	Soft or semi-moist pet food Dry pet food (e.g., kibble) Dog biscuit treat Dried distillers grains Molasses

Water Activity (a_w)	Categories	Animal Food Types
Below 0.60	Low-Moisture Animal Food	Corn syrup solids Extruded wheat pellet Whole egg powder

Some of the intermediate and low a_w animal food types have naturally low a_w (e.g., molasses). We do not discuss those animal food types because a_w does not have to be controlled during processing. Other intermediate and low a_w animal food types, like dry pet food (kibble), pelleted livestock food, and distillers grains start with a high a_w and, through processing, end up with a reduced a_w. This section of this chapter focuses on these types of animal food.

Control of water activity (a_w)

There are two primary ways of reducing a_w in animal food: (1) product formulation (e.g., by adding humectants such as propylene glycol (except in cat food) and salt); and (2) dehydration (drying). In this section of this chapter, we discuss reducing a_w by product formulation. See section 4.5.4 for more information on dehydration/drying.

Every organism has a minimum, optimum, and maximum a_w for growth (see Table 4-8 for the minimum a_w for growth of certain pathogens (Ref. 22)). Yeasts and molds can grow at low a_w; however, 0.85 is generally considered the safe cutoff level for bacterial pathogen growth (Ref. 23).

Table 4-8. Minimum Water Activity (a_w) for Bacterial Pathogen Growth

Pathogen	Minimum a_w (using salt)
Salmonella spp.	0.94
L. monocytogenes	0.92
Pathogenic E. coli	0.95
C. botulinum (depending on type)	0.935-0.97

There are two basic ways for how you can approach product formulation that uses management of a_w for animal food safety. One approach is to closely follow a scientifically established process control for animal food that ensures a sufficiently low a_w. The other approach is to develop your own process control capable of achieving the desired a_w and to ensure its adequacy by taking finished product samples and testing them for a_w.

Exposure to a moist environment will impact the ability of a_w to serve as a preventive control. If you rely on a_w, consider your storage conditions; specifically, protection from water in the environment. For example, a leaking roof could cause stored plant protein meal to become wet, resulting in a meal with a_w that could support the growth of pathogens.

Acidity (pH)

The term "pH" refers to a numeric scale used to describe acidity and alkalinity. The pH reflects the concentration of hydrogen ions and is expressed mathematically as the negative logarithm of the hydrogen ion concentration in moles per liter. The pH scale ranges from 0 to14 with pH less than 7 being acidic, pH equal to 7 neutral, and pH greater than 7 alkaline:

$$\mathbf{pH = -\log[H^+]}$$

Microorganisms can grow only at certain pH levels. Lowering the pH is a method of inhibiting the growth of bacteria rather than a method of killing bacteria. Although many microorganisms held at low pH for an extended period of time will be killed, some pathogenic bacteria, and in particular pathogenic *E. coli*, can survive acidic conditions for an extended period of time, even if their growth is inhibited. For details on the pH values for limiting growth of certain bacterial pathogens, see Table 4-9 (Ref. 24).

Table 4-9. pH Values for Limiting Pathogen Growth

Pathogen	pH Less Than
Salmonella spp.	3.8
L. monocytogenes	4.39
Pathogenic *E. coli*	4.4
C. botulinum	4.6

Acidification

Because an acid pH can inhibit the growth of many bacteria, acidification of animal food could be used as a formulation process control. Acidification is the direct addition of acid to a low-acid animal food (i.e., food with a pH above 4.6). There are a variety of acids (such as acetic acid, lactic acid, and citric acid) that can be used to acidify animal food.

There are several different methods you might use to add acid to the animal food. One method is called direct acidification, where predetermined amounts of acid and the low-acid animal food are added to individual finished product containers during production. In this method, it is important that the processor control the acid-to-animal food ratio. Another method of

acidification is batch acidification. As the name implies, acid and animal food are combined in large batches and allowed to equilibrate. The acidified animal food is then packaged. If you use acidification to significantly minimize pathogenic microorganisms in your animal food, you must validate the process for acidifying that animal food (see 21 CFR 507.47).

Fermentation

During bacterial fermentation of animal food, acid-producing bacteria produce lactic acid, which reduces the pH of the food. Examples of animal food fermented by bacterial fermentation to a pH below 4.6 include haylage and silage. Many of these fermentation activities occur on-farm and operations meeting the "farm" definition in 21 CFR 1.227 are exempt from the PCAF regulation (see 21 CFR 507.5(a)).

Preservatives

Preservatives can be used to prevent the growth of microorganisms – e.g., when used in an animal food that is not thermally processed or not thermally processed to an extent that is sufficient to kill the vegetative cells of non-pathogenic microorganisms (such as spoilage microorganisms) that are capable of reproducing in the animal food under the conditions in which the animal food is stored, distributed, retailed, and held by the user. Preservatives work by denaturing protein, inhibiting enzymes, or altering or destroying the cell walls or cell membranes of microorganisms. A listing of some substances that are generally recognized as safe (GRAS) for use as chemical preservatives is available in 21 CFR part 582, subpart D.

4.5.4 Use of Dehydration/Drying as Process Controls

In the United States, there are three primary methods of dehydration as a process control for biological hazards:

- Forced air drying – used for solid animal food like grains and legumes
- Spray drying – used for liquids and semi-liquids like milk, blood, and blood plasma
- Freeze-drying – used for a limited selection of animal food like some raw pet food

Dehydrated/dried animal food is usually considered shelf-stable due to its low a_w and, therefore, is often stored and distributed unrefrigerated. Examples of shelf-stable dehydrated/dried animal food include freeze-dried raw pet food, milk powders, spray dried animal blood, and dried grains and soybeans.

If you use dehydration/drying as a process control, you should determine if the animal food will require a packaging material that will prevent rehydration of the animal food under the expected conditions of storage and distribution. Additionally, finished animal food packaging and package closures should be free of gross defects that could expose the animal food to moisture during storage and distribution.

Use of the dehydration process can be an effective method for preventing or significantly minimizing deterioration of animal food. Deterioration of animal food includes the loss of

palatability or nutritive value typically associated with the animal food. This deterioration could be a safety concern because animals are often fed the same food containing the same ingredients for prolonged periods of time. Food refusal or consumption of animal food containing inadequate amounts of nutrients may result in poor productivity or health issues.

4.6 Preventive Controls for Chemical Hazards

4.6.1 Preventive Controls for Nutrient Deficiencies and Toxicities

As discussed in Chapter 3, nutrient deficiencies or toxicities are considered chemical hazards for animal food and FDA has a history of recalls of animal food due to this type of chemical hazard. Depending on your facility, the type of animal food, and the intended species (and life stage) of animals, you may determine that a nutrient deficiency or toxicity hazard is a known or reasonably foreseeable hazard that requires a preventive control.

Many nutrient deficiency or toxicity hazards occur before or during processing, for example, due to a miscalculation in the initial recipe/formulation of an animal food for an intended species or life stage, inadvertent addition of the wrong mineral mix to a batch of animal food, or failure to account for the effects some processing procedures (such as LACF thermal processing or irradiation of animal food) have on certain nutrients. Implementation of process controls would be appropriate for many nutrient deficiency or toxicity hazards. Though preventive controls for nutrient deficiencies or toxicities can vary, we describe a few examples.

Essential nutrients in your animal food need to be present at the levels needed by the intended animal species (and life stage) and cannot be present in low or excessive levels if the levels could result in a nutrient deficiency or toxicity hazard. For example, vitamin D is a known or reasonably foreseeable nutrient deficiency or toxicity chemical hazard for some types of animal food. Past recalls of animal food include both those for vitamin D excess and vitamin D deficiencies (see section 3.4.2 in Chapter 3). If you identify vitamin D deficiency or toxicity in your animal food as a hazard requiring a preventive control, your preventive control will depend on your manufacturing procedures and could include several types of controls. Ensuring you have the proper nutrient recipe/formulation for a specific species (and life stage) could be one control. An animal nutritionist or similarly trained individual should prepare the recipe/formulation. Confirming you receive the correct ingredient from your supplier, e.g., by performing a visual check of the label or certificate of analysis to ensure receipt of the appropriate ingredient/component and concentration level, may also be a control. Another control could be one to ensure that the animal food manufacturing equipment is capable of producing a homogeneous animal food. For example, a large mixer that is not filled with the minimum volume of ingredients recommended by the manufacturer may not mix a small batch of animal food adequately, which could result in the vitamin D not being uniformly distributed throughout the animal food (i.e., deficient in some parts, excessive in others).

You should regard thiamine deficiency as known or reasonably foreseeable chemical hazard for cat food that is thermally processed as an LACF product. If you are manufacturing a cat food that will undergo LACF thermal processing, you would likely determine that thiamine deficiency is a chemical hazard requiring a preventive control. One process control could include the

addition of extra thiamine to the cat food to account for the loss during processing. Testing thiamine levels of processed cat food, at a frequency deemed necessary and appropriate, could be an additional process control, or a verification activity to ensure the addition of extra thiamine is effective.

You should regard copper excess as a known or reasonably foreseeable chemical hazard for sheep food. If you are manufacturing food for cattle that requires copper at levels that would be toxic to sheep, and you manufacture food for sheep on the same equipment, you would likely determine that copper excess is a known or reasonably foreseeable nutrient toxicity hazard requiring a preventive control. A preventive control you could implement is a combination of sequencing of animal food production and proper flushing of equipment after cattle food production. Sequencing would ensure any food for sheep is manufactured prior to any food for cattle. You could implement additional controls so there is not an inadvertent mix up by an employee, to ensure the proper mineral supplement containing copper is added to the appropriate animal food (cattle versus sheep). And, you could add control procedures for labeling of finished animal food to ensure a bag of food for cattle (with higher levels of copper) is not mistakenly labeled as sheep food.

The following is an example of preventive controls for a nutrient deficiency or toxicity hazard. You are manufacturing animal food using a mineral premix received from a supplier and you have identified a nutrient deficiency or toxicity hazard. During your hazard evaluation, you find there is a reasonable probability that exposure to the nutrient deficiency or toxicity hazard from that premix will result in serious adverse health consequences or death to humans or animals. You determine nutrient deficiency or toxicity is a hazard requiring a preventive control. You could implement a preventive control to analyze the premix to ensure it meets your specifications. If you are a receiving facility that relies on your supplier to control the nutrient deficiency or toxicity hazard you have determined requires a preventive control, you must establish and implement a risk-based supply-chain program (see 21 CFR 507.105). Because there is a reasonable probability that exposure to a nutrient deficiency or toxicity hazard from that premix will result in serious adverse health consequences or death to humans or animals, your supplier verification activity must be an onsite audit of your supplier (conducted before using the raw materials or other ingredients and at least annually after your initial onsite audit), unless you can provide a written determination that other verification activities and/or less frequent onsite audits of the supplier provide adequate assurance that the nutrient deficiency or toxicity hazard is controlled. (See 21 CFR 507.130(b)(1) and (2)). For example, you may make a written determination that your approved supplier can test each lot of premix for the hazard and provide you with a Certificate of Analysis or other documentation for you to review and assess, in addition to quarterly testing that you conduct to verify the analytical results.

See section 4.9 for a summary of the supply-chain controls found in 21 CFR part 507, subpart E. For more information and our current thinking about supply-chain programs see our draft GFI #246, entitled "Hazard Analysis and Risk-Based Preventive Controls for Food for Animals: Supply-Chain Program."[17]

[17] https://www.fda.gov/media/113923/download.

You might identify specific CGMPs as your preventive control for certain nutrient deficiencies or toxicities. If you do this, the specific CGMP must be included in your food safety plan as your written preventive control (see 21 CFR 507.31) along with the required preventive control management components (see 21 CFR 507.39).

4.6.2 Drying and Storage Conditions as Preventive Controls for Mycotoxins

Mycotoxins are toxic metabolites produced by certain fungi (e.g., molds) that can infect and proliferate on raw agricultural commodities (e.g., grains such as wheat and corn, peanuts, fruits, and tree nuts) in the field and during storage (see Chapter 3, section 3.4.1). Growth of toxigenic fungi during storage and transportation can be enhanced by improper drying or rewetting of the crop from rain or condensation. Thus, proper drying and maintaining appropriate storage conditions could be used as preventive controls that can significantly minimize or prevent the growth of mold and production of mycotoxins in storage.

By far the most critical environmental factors determining whether a raw agricultural commodity will support mold growth are temperature, moisture content, and time. In storage, each of these parameters can be manipulated to prevent mold growth in a raw agricultural commodity. The control of moisture is the principal preventive control for preventing mold growth. Although low-temperature storage can help inhibit mold growth in some conditions, large-scale storage of raw agricultural commodities generally takes place in structures that do not provide for temperature control. Thus, low-temperature storage generally is not a viable preventive control for mycotoxins during the storage of raw agricultural commodities.

4.6.3 Sequencing and Flushing as Preventive Controls for Drug Carryover

If a facility does not have dedicated equipment for manufacturing certain types of animal food, then sequencing and flushing are procedures that could be used to prevent or significantly minimize a drug carryover hazard.

Sequencing involves scheduling the production of animal food containing certain drugs (e.g., ionophores or other antimicrobials) to occur after the production of nonmedicated animal food to minimize the potential for cross-contamination.

Flushing is a method to help remove drugs or animal food that may be left in or on the equipment after production. Flushing is the process of running an ingredient through the manufacturing equipment and associated handling equipment (e.g., conveyors) after the production of a batch of medicated animal food, for the purpose of removing any drug left in or on the equipment. Abrasive flushing material such as corn, soybean meal, and peanut hulls, is helpful after manufacturing a medicated animal food with high fat content or containing molasses that may stick to equipment. Depending on the facility and the animal food manufactured, flushing may need to be conducted more often than at the end or start of the day. Any flushing method used as a preventive control must be validated as required by 21 CFR 507.47.

In a medicated feed mill, required employee training in the principles of animal food hygiene and

animal food safety (see 21 CFR 507.4(b)(2)) should include information about the drugs used by the facility and the potential for illness or injury to animals when those drugs cross-contaminate nonmedicated animal food. See 21 CFR part 225 for additional medicated feed regulations.

4.7 Preventive Controls for Physical Hazards

4.7.1 Preventive Controls for Metal Hazards

Metal-to-metal contact during processing can introduce metal fragments into products. For example, metal fragments can break off during mechanical cutting and blending operations. Some metal equipment has parts that can break or fall off, such as wire-mesh belts. You can control metal hazards by using physical separation techniques (e.g., magnets, sieves, screens), electronic or X-ray metal detection devices, and by regularly inspecting at-risk equipment for signs of damage.

The effectiveness of physical separation techniques depends on the nature of the animal food. For example, these measures are more likely to be effective in liquids, powders, and similar animal food ingredients and finished animal food in which the metal fragment will not become imbedded.

The use of electronic metal detectors is complex, especially with regard to stainless steel, which is difficult to detect. The orientation of the metal object in the animal food affects the ability of the equipment to detect it. For example, if a detector is not properly calibrated and is set to detect a sphere 0.08 inch (2 mm) in diameter, it may fail to detect a stainless steel wire that is smaller in diameter but up to 0.9 inch (24 mm) long, depending on the orientation of the wire as it travels through the detector. Processing conditions, such as ambient humidity or product acidity, may affect the conductivity of the product and create an interference signal that may mask metal inclusion unless the detector is properly calibrated. You should consider these factors when calibrating and using such equipment.

X-ray devices can also be used for metal detection. One advantage of using an X-ray device is that the device can also detect non-metal foreign objects such as glass fragments.

Also, preventive controls can include scheduled maintenance of equipment and periodic examination of your processing equipment for damage that can cause the introduction of metal fragments into the animal food. You should particularly look at equipment that is prone to breaking, such as saw blades, or equipment that has metal-to-metal contact. The success of this strategy depends in large part on the nature of the equipment inspected and the frequency of the inspection. However, this approach will not necessarily prevent metal fragments from being incorporated into the product in all cases but may enable you to separate products that may have been exposed to metal fragments. Visually inspecting equipment for damaged or missing parts may only be feasible with relatively simple equipment, such as band saws, small orbital blenders, and wire-mesh belts. More complex equipment that contains many parts, some of which may not be readily visible, may not be suitable for visual inspection and you should use controls such as metal detection or physical separation techniques.

4.7.2 Preventive Controls for Glass Hazards

Glass fragments can be introduced into animal food when processing occurs under overhead light fixtures and light bulbs made of glass that can fracture. Animals may ingest these glass fragments which can cause serious injury (e.g., laceration or perforation of the gastrointestinal tract and choking). Light bulbs, fixtures, skylights, or other glass items suspended over exposed animal food in any step of preparation must be shatter-resistant to protect against the contamination of animal food from glass breakage (see 21 CFR 507.17(b)(5)).

4.7.3 Preventive Controls for Hard Plastic Hazards

Hard plastic can be introduced into animal food at any time during processing when tools and equipment (e.g., scoops, buckets, paddles, sieves, and screens) wear down. Normal use and processing may wear down these tools or equipment over time resulting in fatigue, cracking, and breaking. As a preventive measure, it is important to regularly examine plastics for cracks throughout your facility. Plastic can also be present in incoming ingredients (e.g., animal identification tags in rendered products, or packaging material from products originally intended for human food used for animal food). Preventive controls that can be used to significantly minimize or prevent hard plastics in animal food at receiving or during manufacturing include visually inspecting animal food and using physical separation techniques (e.g., sieves and screens).

4.7.4 Preventive Controls for Conditions of Animal Food That Can be Hazards

Conditions of the animal food that can cause illness or injury in animals include physical, mechanical, and other characteristics of animal food (e.g., particle size, hardness, surface roughness, digestibility, and ability to soften when moistened). Preventive controls will vary depending on the type of animal food and the specific condition of the animal food that you have determined requires a preventive control.

If you determine particle size (e.g., too small or too large) is a condition of animal food hazard that requires a preventive control, you could address particle size through process controls. If you are reducing the particle size during manufacturing, your process controls would ensure the process is achieving the desired particle size, for example, through selection of the hammer-mill screen size.

Another condition of animal food hazard you might identify is excessive hardness or poor digestibility. Recipe/formulations and manufacturing processes could impact the hardness and/or digestibility of animal food. For example, starch is used in animal food for nutritive value and as a thickening agent. When starch is gelatinized, the chemical structure of the starch is changed, providing digestive enzymes in saliva access to the glycosidic linkages in the starch. The enzymes soften the animal food during chewing and make it easier for the animal to swallow. If you have identified the inability to soften when moistened as a condition of animal food hazard that requires a preventive control for your animal food, you might use a supply-chain program to ensure starch meets your specifications (e.g., iodine value, solubility, and viscosity). You also may rely on your manufacturing process to gelatinize the starch. In this

situation, you may determine that you need to implement a process control to ensure acceptable gelatinization of the starch to significantly minimize or prevent indigestible animal food. Your process control would include parameters for the processing (e.g., temperature, time, pressure, and moisture content) necessary to gelatinize the starch in your food.

4.8 Sanitation Controls

Sanitation controls include procedures, practices, and processes to ensure that the facility is maintained in a sanitary condition adequate to significantly minimize or prevent hazards such as environmental pathogens and biological hazards due to employee handling. Sanitation controls must include, as appropriate to the facility and the animal food, procedures, practices, and processes for the: (1) cleanliness of animal food-contact surfaces, including animal food-contact surfaces of utensils and equipment; and (2) prevention of cross-contamination from insanitary objects and from personnel to animal food, animal food-packaging material, and other animal food-contact surfaces and from raw product to processed product. See 21 CFR 507.34(c)(2).

Animal food CGMPs include requirements for sanitation of the plant (see 21 CFR 507.19). These requirements are applicable to the cleanliness of equipment, utensils, buildings, structures, and fixtures. To comply with these CGMP requirements, cleaning procedures should take place routinely, often daily, in your facility. To facilitate sanitation, there are requirements for the design and construction of equipment and utensils (see 21 CFR 507.22(a)).

Some of your sanitation procedures, practices, and processes used in your facility for general cleaning and sanitation may be performed to comply with CGMP requirements. Other sanitation procedures, practices, and processes may be sanitation controls if used to significantly minimize or prevent a biological hazard. You determine which hazards require a sanitation control through your hazard analysis. For example, you may determine a sanitation control is needed in addition to the general facility cleaning if there is a biological hazard such as *L. monocytogenes* that you determined requires a preventive control. The sanitation control is the cleaning and sanitizing you conduct on animal food-contact surfaces of utensils and equipment to significantly minimize or prevent *L. monocytogenes*. Because the cleaning and sanitizing are used as a sanitation control, they are subject to the preventive control management components in 21 CFR 507.39.

For your sanitation controls to be effective, you should first assess the cleaning procedures, practices, and processes that you have in place to comply with the CGMP requirements. See our GFI #235 entitled "Current Good Manufacturing Practice Requirements for Food for Animals."[18] Equipment design that ensures that all surfaces can be accessed and cleaned (see 21 CFR 507.22(a)(1)) is essential for the effective application of sanitation controls. For clarification of the terms "cleaning" and "sanitize", see section 4.8.1. Considerations for equipment design include factors such as whether equipment includes hollow bodies or poorly developed welds and seams, as well as whether ease of disassembly allows adequate access to all animal food-contact surfaces to ensure thorough cleaning and sanitation. Design considerations also apply to animal food facility structures (e.g., floors, walls, piping, and ceilings) to facilitate

[18] https://www.fda.gov/media/97464/download.

cleaning and sanitation practices. Sources of scientific and technical information also can be useful in establishing sanitation controls (Refs. 25, 26, and 27).

4.8.1 Cleaning Strategies and Sanitation Controls

The PCAF regulation does not define the term "cleaning." In this guidance, we use the term "cleaning" to mean the removal of soil, animal food residue, dirt, grease or other objectionable matter. Cleaning procedures, practices, and processes are generally considered part of a facility's general sanitation program. The PCAF regulation defines "sanitize" to mean to adequately treat cleaned surfaces by a process that is effective in destroying vegetative cells of pathogens, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the product or its safety for animals or humans (21 CFR 507.3). Although cleaning operations and sanitizing operations often are conducted separately – and sequentially – some systems (such as steam systems) both clean and sanitize surfaces; we consider that such systems satisfy the definition of sanitize.

The cleaning procedures and any sanitation controls you use will vary based on the nature of your facility, such as whether your facility has a dry or wet processing environment.

Table 4-10 describes three types of cleaning strategies that you can use to remove soil, food residue, dirt, grease, or other objectionable matter depending upon the processing environment (wet or dry). Table 4-10 also includes some recommendations when using these cleaning strategies.

Table 4-10. Types of Cleaning Strategies

Cleaning Strategy	Description	Recommendations
Wet Cleaning	Uses water-based and/or wet chemical cleaning solutions Typically used for wet processing environments	When feasible, initially dry clean area or equipment Use water on an as needed basis Use water only in required areas When feasible, avoid using water in a manner that could aerosolize (e.g., high pressure) When animal food-contact surfaces are wet-cleaned, the surfaces must, when necessary, be thoroughly dried before subsequent use (see 21 CFR 507.19(b)(1))

Cleaning Strategy	Description	Recommendations
Controlled Wet Cleaning	Uses a limited amount of water Typically used for dry processing environments	When feasible, initially dry clean area or equipment Use only as much water as is necessary Move specific pieces of equipment to a designated area for cleaning and sanitizing and dry them prior to returning them to the dry manufacturing area When animal food-contact surfaces are wet-cleaned, the surfaces must, when necessary, be thoroughly dried before subsequent use (see 21 CFR 507.19(b)(1)), and complete drying should immediately follow after the controlled wet cleaning
Dry Cleaning	The physical removal of residues (e.g., animal food particles and dust) without water Typically used for dry processing environments	Remove animal food residues by actions such as sweeping, brushing, scraping, flushing or vacuuming the residues from equipment surfaces and the facility environment Be careful to not distribute animal food particles to other equipment or areas during removal Compressed air must be used in a way that protects against the contamination of animal food (see 21 CFR 507.22(e)) (e.g., does not blow dirt, debris, or other contaminants into the animal food or onto animal food-contact surfaces)

Moisture control is important in preventing contamination with undesirable microorganisms. For example, water in a dry processing environment is one of the most significant risk factors for *Salmonella* contamination because the presence of water allows for pathogen growth leading to product contamination from the environment or from insanitary food contact surfaces. You should maintain dry conditions at all times when you determine that *Salmonella* in the environment is a hazard requiring a preventive control, except for the occasions when you decide that controlled wet cleaning is necessary. Potential problems arise when there is visible water present in the dry areas or when there are areas in which standing water has dried. *Salmonella* may be found both in wet spots and in spots where standing water has dried. Therefore, dry cleaning or controlled wet cleaning practices should be considered for use as a component of

sanitation controls in a dry processing environment.

Wet processing operations are typically cleaned using wet cleaning practices. However, the use of water should be minimized even in facilities that are wet cleaned. Wet floors can serve as potential sources for *L. monocytogenes* via the movement of people and equipment and material handling items such as totes and pallets. Cleaning and sanitizing floors, including drains, could help reduce the potential for *L. monocytogenes* to establish in the environment. *L. monocytogenes* is not usually airborne; however, in wet environments, aerosols from high pressure water hoses used during cleaning operations help spread *L. monocytogenes* throughout the environment and from one surface (e.g., floors) to another surface (e.g., animal food-contact surfaces, such as conveyors, tables, and animal food containers). Cleaning and sanitizing may be an important sanitation control for facilities that have determined they need to control *L. monocytogenes* because they are producing animal food such as raw pet food which may be exposed to the environment prior to packaging.

If you determine sanitizing is necessary, you should sanitize animal food contact surfaces and other areas as appropriate after the surfaces are cleaned. You should use all sanitizers in accordance with the EPA-registered (or similar registration in other countries) label use instructions, including approval for use in food establishments.

For additional information on the impact of wet and dry processing environments on *L. monocytogenes* and *Salmonella*, see Chapter 3, section 3.3.4.

4.8.2 Use of Sanitation Controls to Prevent Cross-Contamination

As noted previously in this section, sanitation controls must include, as appropriate to the facility and the animal food, procedures, practices, and processes for the prevention of cross-contamination from insanitary objects and from personnel to animal food, animal food packaging material, and other animal food-contact surfaces and from raw product to processed product. See 21 CFR 507.34(c)(2)(ii).

Table 4-11 describes some practices that you can use to prevent cross-contamination of processed animal food from insanitary objects, personnel, and raw product.

Table 4-11. Practices to Prevent Cross-Contamination

Practice	Description
Hygienic Zoning	Hygienic zoning for separation and segregation of process operations such as raw vs. work-in-process vs. finished product; wet vs. dry; personnel and materials traffic flow; air balance
Hygienic Zone Specific Cleaning	Dedicated cleaning and sanitation practices (including sanitizing) within hygiene zones

The objective of hygienic zoning is to reduce the potential for transient pathogens to enter sensitive areas in your facility. You should determine the need for, and scope of, a hygienic zoning program based on the outcome of your hazard analysis and considering your facility and type of animal food. In determining the need for, and scope of, a hygienic zoning program, you should take into account the design of your plant, packaging, personnel and ingredient traffic flows, and any cross over areas. You also should consider potential contaminants from raw materials, air flow, support areas, and other activities taking place in your facility.

Hygienic zoning is more likely to have application in the production of pet food than in facilities producing livestock food. For example, a facility that makes pet food might decide it needs to implement a hygienic zoning program to prevent cross-contamination with *Salmonella* spp. *or L. monocytogenes* since the pet food may be exposed to the environment prior to packaging.

4.9 Supply-Chain Controls

A supply-chain control is a type of preventive control (21 CFR 507.34(c)(3)). The requirements for implementing a supply-chain program to control a hazard that must be controlled by a supplier are found in 21 CFR part 507, subpart E.

The requirements for a supply-chain control differ from those for a process control or sanitation control. If a supply-chain program is needed based on the outcome of your hazard analysis, you must be familiar with the requirements of the supply-chain program. The sections in 21 CFR part 507, subpart E are as follows:

- Requirement to establish and implement a supply-chain program (21 CFR 507.105)
- General requirements applicable to a supply-chain program (21 CFR 507.110)
- Responsibilities of the receiving facility (21 CFR 507.115)
- Using approved suppliers (21 CFR 507.120)
- Determining appropriate supplier verification activities (including determining the frequency of conducting the activity) (21 CFR 507.125)
- Conducting supplier verification activities for raw materials and other ingredients (21 CFR 507.130)
- Onsite audit (21 CFR 507.135)
- Records documenting the supply-chain program (21 CFR 507.175)

We provide FDA's current thinking on the requirements of the supply-chain program in our draft GFI #246 entitled "Hazard Analysis and Risk-Based Preventive Controls for Food for Animals: Supply-Chain Program."[19]

4.10 Recall Plan

[19] https://www.fda.gov/media/113923/download.

For animal food with a hazard requiring a preventive control, you must establish a written recall plan for the animal food. (See 21 CFR 507.38(a)(1).) The written recall plan must include procedures that describe the steps to be taken, and assign responsibility for taking those steps, to perform the following actions as appropriate to the facility:

- directly notify the direct consignees of the animal food being recalled, including how to return or dispose of the affected animal food (21 CFR 507.38(b)(1))
- notify the public about any hazard presented by the animal food when appropriate to protect human and animal health (21 CFR 507.38(b)(2))
- conduct effectiveness checks to verify that the recall is carried out (21 CFR 507.38(b)(3))
- appropriately dispose of recalled animal food – e.g., through reprocessing, reworking, diverting to a use that does not present a safety concern, or destroying the animal food (21 CFR 507.38(b)(4))

We recommend that you consult our general guidance on policy, procedures, and industry responsibilities regarding recalls in 21 CFR part 7, subpart C (sections 7.40 through 7.59) and on FDA's website, "Industry Guidance for Recalls."[20]

Careful planning when developing a recall plan can increase recall efficiency. You must assign responsibility for performing all procedures in your recall plan (21 CFR 507.38(a)(2)). You may consider assigning responsibilities to a position rather than specifying an individual by name. Assigning responsibilities to a position would not require you to update the recall section of your food safety plan if you have a change in personnel. For facilities that have multiple shifts, this may allow you to initiate a recall faster since you would not have to wait for an individual who may work on a different shift. However, we also recommend you ensure each person in that position, to which the responsibility is assigned, understands the steps to be taken during a recall.

A recall can be disruptive to your operation and business, but there are steps you can take in advance to minimize this disruptive effect:

- Adequately code animal food to make possible positive lot identification and to facilitate effective recall of all violative lots.

- Maintain such animal food distribution records as are necessary to facilitate location of products that are being recalled. You may wish to maintain such records for a period of time that exceeds the shelf life and expected use of the product as a matter of business practice.

4.11 References for Chapter 4

1. Food Safety Preventive Controls Alliance. 2016. "Preventive Controls for Animal Food Participant Manual". First Edition v.1.0.

[20] https://www.fda.gov/safety/recalls-market-withdrawals-safety-alerts/industry-guidance-recalls

2. National Advisory Committee on Microbiological Criteria for Foods. 1998. "Hazard Analysis and Critical Control Point Principles and Application Guidelines". *Journal of Food Protection* 61 (9): 1246-1259.

3. Codex Alimentarius Commission. 2003. "Recommended International Code of Practice General Principles of Food Hygiene CAC/RCP1-1969, Rev. 4-2003[1]". Accessed July 19, 2021. http://www.mhlw.go.jp/english/topics/importedfoods/guideline/dl/04.pdf.

4. Grocery Manufacturers Association. 2009. "Control of *Salmonella* in Low-Moisture Foods". Accessed July 19, 2021. http://graphics8.nytimes.com/packages/pdf/business/20090515_moss_ingredients/SalmonellaControlGuidance.pdf.

5. American Feed Industry Association. 2010. "*Salmonella* Control Guidelines". Accessed July 19, 2021. http://ucfoodsafety.ucdavis.edu/files/172958.pdf.

6. Food Safety Preventive Controls Alliance. 2016. "Preventive Controls for Human Food". First Edition v.1.2.

7. Kijlstra, A., and E. Jongert. 2008. "Control of the Risk of Human Toxoplasmosis Transmitted by Meat". *International Journal for Parasitology* 38 (12): 1359-1370. DOI:10.1016/j.ijpara.2008.06.002.

8. Lindsay, D. S., *et al*. 2006. "Effects of High-Pressure Processing on *Toxoplasma gondii* Tissue Cysts in Ground Pork". *Journal of Parasitology* 92 (1): 195-196. DOI: 10.1645/GE-631R.1.

9. Jones, J. L., and J. P. Dubey. 2012. "Foodborne Toxoplasmosis". *Clinical Infectious Diseases* 55 (6): 845-851. DOI: 10.1093/cid/cis508.

10. Food and Drug Administration. 2000. "Kinetics of Microbial Inactivation for Alternative Food Processing Technologies – Overarching Principles: Kinetics and Pathogens of Concern for all Technologies". Accessed June 2, 2022. https://www.fda.gov/media/103619/download.

11. Lacroix, M. 2014. "Chapter 16: Irradiation". In *Emerging Technologies for Food Processing*, edited by Sun, D. W., 293–312. London: Elsevier Academic Press.

12. Tiwari, B. K. 2014. "Chapter 17: New Chemical and Biochemical Hurdles". In *Emerging Technologies for Food Processing*, edited by Sun, D. W., 313-325. London: Elsevier Academic Press.

13. Niemira, B. A. 2014. "Chapter 18: Decontamination of Foods by Cold Plasma". In *Emerging Technologies for Food Processing*, edited by Sun, D. W., London: Elsevier Academic Press.

14. Tao, Y., *et al*. 2014. "Chapter 1: High-Pressure Processing of Foods: An Overview". In *Emerging Technologies for Food Processing,* edited by Sun, D.W., 3-24. London: Elsevier Academic Press.

15. Farkas, J., *et al*. 2014. "Chapter 27: Food Technologies: Food Irradiation". In *Encyclopedia of Food Safety*, edited by Motarjemi, Y., Moy, G., and Tood E., 178-186. Waltham: Elsevier.

16. Caulfield, C. D., *et al*. 2008. "Effects of Gamma Irradiation and Pasteurization on the Nutritive Composition of Commercially Available Animal Diets". *Journal of the American Association for Laboratory Animal Science* 47 (6): 61-66.

17. Zhu, J. T, *et al*. 2012. "Toxicological Evaluation of Chicken-Breast Meat with High-Dose Irradiation". *Journal of Integrative Agriculture* 11 (12): 2088-2096. DOI: 10.1016/S2095-3119(12)60467-5.

18. Child, G., *et al*. 2009. "Ataxia and Paralysis in Cats in Australia Associated with Exposure to an Imported Gamma-Irradiated Commercial Dry Pet Food". *Australian Veterinary Journal* 87 (9): 349-351. DOI: 10.1111/j.1751-0813.2009.00475.x.

19. Food and Drug Administration. 2017. "Food Code". Accessed July 19, 2021. https://www.fda.gov/food/fda-food-code/food-code-2017.

20. Cauvain, S.P., and L.S. Young. 2011. Equilibrium Relative Humidity (Water Activity). In *Food and Beverage Stability and Shelf Life*, edited by Kilcast, D. and Subramaniam, P., 667. Cambridge: Woodhead Publishing.

21. Padua, G.W. 2014. Water Activity. In *Encyclopedia of Agricultural, Food, and Biological Engineering,* edited by Heldman, D.R. and Moraru, C.I., 1837-1839. Boca Raton: CRC Press.

22. International Commission on Microbiological Specification. 1996. "Microorganisms in Foods 5: Characteristics of microbial pathogens. Blackie Academic & Professional.

23. Food and Drug Administration. 2015. "Water Activity (a_w) in Foods". Accessed July 19, 2021. https://www.fda.gov/ICECI/Inspections/InspectionGuides/InspectionTechnicalGuides/ucm072916.htm.

24. United States Department of Agriculture. 2012. Introduction to the Microbiology of Food Processing. In *Small Plant News Guidebook Series,* 40.

25. Holah, J. T. 2014. "Chapter 9: Cleaning and Disinfection Practices in Food Processing". In *Hygiene in Food Processing - Principles and Practice*, edited by Lelieveld, H. L. M., J. T. Holah and Napper D., Cambridge: Elsevier Publishing.

26. Marriott, N. G., and R. B. Gravani. 2010. “Chapter 8: Quality Assurance for Sanitation”. In *Principles of Food Sanitation*, 116-140. New York: Springer.

27. Marriott, N. G., and R. B. Gravani. 2010. “Chapter 9: Cleaning Compounds”. In *Principles of Food Sanitation*, 141-164. New York: Springer.

CHAPTER 5 – OVERVIEW OF PREVENTIVE CONTROL MANAGEMENT COMPONENTS

5.1 Purpose of this Chapter

The guidance provided in this chapter is intended to help you implement the preventive control management components (PC management components) that are part of your food safety plan. See 21 CFR 507.39. If you have determined there are no hazards requiring preventive controls for your animal food, you would not need to establish PC management components.

5.2 Overview of Preventive Control Management Components

The PC management components include monitoring, corrective actions and corrections, verification activities (including validation and verification of implementation and effectiveness), and their associated records. You must apply appropriate PC management components to ensure the effectiveness of your preventive control(s) identified in your food safety plan, taking into account the nature of the preventive control and its role in your facility's animal food safety system. See 21 CFR 507.39. This chapter will focus on PC management components associated with process controls, sanitation controls, and other preventive controls.

5.3 Who is Responsible for Conducting Preventive Control Management Component Activities?

In this Chapter, we discuss two types of individuals who are responsible for conducting PC management components, a "preventive controls qualified individual" (PCQI) and a "qualified individual" (QI) (see Box 5-1). As discussed in Chapter 1, your PCQI is a qualified individual who successfully completed training in the development and application of risk-based preventive controls or is otherwise qualified through job experience to develop and apply a food safety system. The PCQI must prepare (or oversee the preparation of) your food safety plan. Specifically, for PC management components, PCQIs must conduct or oversee validation of preventive controls and some verification of implementation and effectiveness activities (see 21 CFR 507.53(a)). The PCQI may designate another individual to conduct these activities provided the individual is a QI and the PCQI maintains oversight.

Box 5-1. Definition of Qualified Individual

Qualified Individual (QI)

A person who has the education, training, or experience (or a combination thereof) necessary to manufacture, process, pack, or hold safe animal food as appropriate to the individual's assigned duties. A qualified individual may be, but is not required to be, an employee of the establishment. (21 CFR 507.3)

In many cases, a QI may be assigned the responsibility for conducting the PC management component activities. The individual(s) who conducts and generates records for monitoring, corrective actions and corrections, and other activities must be qualified to perform these assigned duties. See 21 CFR 507.4(b)(1). For a discussion of training required for a QI, see our GFI #235 entitled "Current Good Manufacturing Practice Requirements for Food for Animals."[21]

5.4 Recordkeeping Requirements for Preventive Control Management Components

The specific records required for each PC management component are found in their respective sections of the PCAF regulation:

- 21 CFR 507.40 – Monitoring
- 21 CFR 507.42 – Corrective actions and corrections
- 21 CFR 507.45 – Verification (including validation and verification of implementation and effectiveness)

These records are subject to the recordkeeping requirements in 21 CFR part 507, subpart F – Requirements Applying to Records That Must Be Established and Maintained. The records must meet the various requirements in 21 CFR 507.202. For example, the records must contain the actual values and observations obtained during monitoring and as appropriate during verification; be created concurrently with the activity documented including the date and if necessary the time; and, be signed or initialed by the individual performing the activity (see 21 CFR 507.202(a) and (b)).

In general, records must be retained for at least two years (see 21 CFR 507.208(a)(1)). Some records are required to be retained longer, such as those related to the general adequacy of the equipment or processes being used at the facility (see 21 CFR 507.208(b)). Results of scientific studies and evaluations (i.e., used for validation) must be retained for at least two years after their use is discontinued (e.g., discontinued because you have updated the records documenting validation). See 21 CFR 507.208(b). The recordkeeping requirements are discussed further in each PC management component section of this chapter.

5.5 Preventive Control Management Components Examples

We use two animal food scenarios throughout this chapter to help illustrate the requirements we describe in this chapter. The scenarios are simplified for purposes of this guidance and focus on a single hazard and preventive control for each facility. We use different employee position titles in the examples, but all individuals are QIs. See Boxes 5-3a and b through 5-12a and b for the two example scenarios.

Boxes 5-2a and 5-2b provide an introduction to the two scenarios.

[21] https://www.fda.gov/media/97464/download.

Box 5-2a. PC Management Components Example – Introduction

***Salmonella* in dog biscuit treats:** At your facility, you bake dog biscuits containing chicken by-products. Based on your hazard analysis, you identify *Salmonella* as a known or reasonably foreseeable biological hazard and determine that this hazard requires a preventive control. The preventive control you identify is thermal processing (time and temperature preventive control) implemented by baking the biscuits in an oven to significantly minimize *Salmonella.* You set the minimum parameter value for temperature at 350°F (177°C) and the minimum parameter value for baking time at 15 minutes. In order to ensure the safety of the dog biscuits, you bake them at a temperature of 355°F (179°C). The preventive control is validated by your PCQI before you begin initial production (see Box 5-5a). These procedures (i.e., your preventive control) are written in your food safety plan. Your facility runs 3 shifts daily, 8 hours each, and every seventh day shuts down during the last shift for cleaning. Immediately after exiting the baking chamber, the biscuits are gently cooled down to ambient temperature on an enclosed cooling conveyor that delivers the biscuits to the bagging/packaging machine where they are packaged 20 biscuits per sealed poly bag.

Box 5-2b. PC Management Components Example – Introduction

Monensin in horse food: At your feed mill, you manufacture food for cattle containing the animal drug monensin. You also manufacture horse food using the same equipment. Based on your hazard analysis, you identify monensin in horse food as a known or reasonably foreseeable chemical hazard and determine that this hazard requires a preventive control. You identify and implement as your preventive control daily sequencing and flushing procedures. Your sequencing procedure specifies that horse food must be manufactured prior to animal food containing monensin (e.g., food for beef cattle). Your flushing procedure specifies the amount and type of flush material to use and that flushing must be performed at the end of each day. The preventive control is validated by your PCQI before you begin initial production of horse food (see Box 5-5b). These procedures (i.e., your preventive control) are written in your food safety plan.

5.6 Monitoring

"Monitor" means to conduct a planned sequence of observations or measurements to assess whether control measures are operating as intended (21 CFR 507.3). You must establish and implement written procedures for monitoring preventive controls, including the frequency with which they are to be performed (as appropriate to the nature of the preventive control and its role in your animal food safety system). See 21 CFR 507.40.

Your monitoring procedures should answer five questions:

1. What will be monitored?
2. How will monitoring be done?

3. How often will monitoring be done (frequency)?
4. Who will do the monitoring?
5. What records do I need to document monitoring?

5.6.1 What Will Be Monitored?

What you monitor should be directly related to control of the hazard. For example, for a process control you monitor parameters to ensure the maximum or minimum parameter values, or a combination of parameter values used to control the hazard, are met.

For preventive controls other than process controls, what you monitor depends on the type of preventive control. For example, for sanitation controls, you may monitor that the sanitizer is prepared and applied according to your written procedures.

5.6.2 How Will Monitoring Be Done?

The type of monitoring method you choose will depend on the preventive control you are implementing. You may monitor by using a variety of instruments, laboratory analyses, or visual checks.

Instrumentation may be appropriate for a preventive control that has a parameter that can be measured during processing. For example, you would use instruments to monitor parameters such as pH, a_w, temperature, or pressure.

Laboratory analysis may be conducted using an onsite rapid testing method or conducted off-site by an outside laboratory. For example, if you are controlling the level of aflatoxin in your raw corn, you may use a rapid test to monitor for the presence of aflatoxin.

Visual checks also may be an appropriate monitoring activity, such as observing package integrity to ensure a finished pet food will not be exposed to contaminants from the environment (e.g., looking for broken bags or containers).

5.6.3 How Often Will Monitoring Be Done (Frequency)?

You must monitor the preventive controls with adequate frequency to provide assurance that they are consistently performed (21 CFR 507.40(b)). The frequency of monitoring depends upon the hazard you identify, your preventive control, and the animal food. You may determine that some preventive controls require continuous monitoring while others can be adequately monitored on a less frequent basis.

Continuous monitoring is typically performed by an instrument that produces a continuous record, for example a temperature-chart recorder on an oven. Continuous monitoring is desirable and, in some cases, you may decide it is necessary. Even with continuous monitoring, you should check the paper or electronic record of the continuous monitoring instrument (device) with adequate frequency to provide assurance that the preventive control is being consistently

performed, for example, by determining if there are deviations from the control parameter values.

In some situations, you may decide that continuous monitoring is not necessary. Non-continuous monitoring might include temperature checks at designated points in the production process or samples taken for pH analysis at designated time points during the day. When determining the frequency for non-continuous monitoring, you should consider the variation during normal processing, how close your operating limits are to your parameter values (if appropriate), and how much animal food could be impacted if a deviation occurs. See Chapter 4, section 4.4.1, for more information about operating limits.

You should monitor often enough: (1) to determine the normal variability in what you are measuring or observing, and (2) to detect a deviation. Generally, the greater the time span between measurements, or between checks that procedures are being followed, the more animal food you put at risk. If a measurement or observation shows that a deviation occurred, you should assume that the preventive control was not effective or not implemented correctly following the most recent acceptable measurement or observation.

5.6.4 Who Will Do the Monitoring?

The person conducting the monitoring must be a QI for their assigned duties. See 21 CFR 507.4(b)(1).

5.6.5 What Records Do I Need to Document Monitoring?

You must document your monitoring of preventive controls in records that are subject to verification and records review by a PCQI (see 21 CFR 507.40(c)(1) and 507.49(a)(4)(i)). Records include the documents that are generated during continuous or periodic monitoring.

Records for monitoring refrigeration temperature may be affirmative or exception records. Affirmative monitoring records demonstrate that refrigeration temperature (your preventive control) is under control. See 21 CFR 507.40(c)(2)(i). For example, an affirmative record is the record on which your QI records your refrigerator temperature demonstrating the temperature is controlled or the chart recorder record from the continuous monitoring system.

A continuous monitoring system of refrigeration temperature may generate an exception record if there is a loss of temperature control. Exception records may be adequate in circumstances other than monitoring of refrigeration temperature. See 21 CFR 507.40(c)(2)(ii). When using exception records, a record is generated only when a deviation occurs. For example, if your freezer temperature rises above your parameter value, your computer system generates an exception record demonstrating the rise of temperature and time of deviation. If you use an exception record, you must have evidence that your system is working as intended (see 21 CFR 507.49), such as a record that the system has been challenged by increasing the temperature to a point at which an exception record is generated.

Boxes 5-3a and 5-3b provide examples of monitoring.

Box 5-3a. PC Management Component Example – Monitoring

***Salmonella* in dog biscuit treats:** According to your time and temperature preventive control, you bake your biscuits in a conveyor oven set at a speed to give a 15-minute baking time at 355°F (179°C) to ensure you stay above your minimum parameter value of 350°F (177°C). Your conveyor oven is equipped with a thermocouple probe, a temperature chart recorder, and alarm system that continuously measures oven temperature.

Per your written preventive control procedures, the designated operator does a visual check of the chart recorder every hour to ensure the oven temperature remains at 355°F (179°C) (your 1st monitoring procedure) and documents this in the monitoring record. In addition, the operator uses a stopwatch to check conveyor speed every 2 hours to ensure a 15-minute baking time (your 2nd monitoring procedure) and records the results in the monitoring record.

Box 5-3b. PC Management Component Example – Monitoring

Monensin in horse food: To monitor your sequencing and flushing preventive control, your written procedures state that the designated operator(s) must record the order of each batch of animal food produced that day to document horse food is produced prior to any animal food containing monensin, and to document the flushing of equipment at the end of the day. To accomplish this, the designated operator completes a real-time sequencing production record (your 1st monitoring record) for each batch of animal food produced and a flushing record (your 2nd monitoring record) at the end of the day. Per your written procedures, your sequencing production record contains: the date, the type of animal food produced, the order in which the animal food is to be produced, the time the batch was produced, the name of any drugs used in the batch, the quantity produced, and the batch lot number. Per your written procedures, your flushing record contains: the date, the time the flushing occurred, and the type and amount of material used for flushing.

5.7 Corrective Actions and Corrections

When your preventive control is not properly implemented, you must conduct a corrective action or correction. See 21 CFR 507.42. The purpose of corrective actions is to prevent adulterated animal food from entering commerce. When minor, isolated problems occur that do not directly impact animal food safety, corrections may be appropriate instead of corrective actions.

5.7.1 Corrective Actions

As appropriate to the nature of the hazard and the nature of the preventive control, you must establish and implement written corrective action procedures you must take if preventive controls are not properly implemented (21 CFR 507.42(a)(1)). As appropriate, your written corrective action procedures also must include procedures to address the presence of a pathogen or appropriate indicator organism in an animal food detected as a result of your product testing

(see 21 CFR 507.42(a)(1)(i)), and the presence of an environmental pathogen or appropriate indicator organism detected through your environmental monitoring (21 CFR 507.42(a)(1)(ii)).

Specifically, the corrective action procedures must describe the steps to be taken to ensure that:

- appropriate action is taken to identify and correct the problem that has occurred with the implementation of a preventive control (21 CFR 507.42(a)(2)(i))
- appropriate action is taken when necessary to reduce the likelihood that the problem will recur (21 CFR 507.42(a)(2)(ii))
- all affected animal food is evaluated for safety (21 CFR 507.42(a)(2)(iii))
- all affected animal food is prevented from entering into commerce if you cannot ensure the affected animal food is not adulterated (21 CFR 507.42(a)(2)(iv))

A predetermined corrective action procedure has advantages. For example, the written procedure provides detailed instructions for an employee to follow in the event of a deviation in applying a preventive control and is prepared at a time when an emergency situation is not calling for an immediate decision.

You may not be able to anticipate all the problems that could happen and include them in your written corrective action procedures; however, you still must take corrective actions when an unanticipated problem occurs. You must take appropriate corrective actions if:

- you do not properly implement a preventive control and you have not established a written corrective action procedure (see 21 CFR 507.42(b)(1)(i));
- your preventive contol (or combination of controls) or your food safety plan as a whole is ineffective (see 21 CFR 507.42(b)(1)(ii)); or
- a review of your records (as required in 21 CFR 507.49(a)(4)) finds that your records are not complete, the activities you conducted did not follow your food safety plan, or you did not make appropriate decisions about corrective actions (see 21 CFR 507.42(b)(1)(iii)).

The corrective actions for the problems in the bulleted list immediately above include standard corrective action procedures (i.e., identify and correct the problem, take steps to reduce the likelihood the problem will recur, evaluate all affected animal food for safety, and prevent adulterated animal food from entering commerce). See 21 CFR 507.42(b)(2)(i)-(iv). In addition, when appropriate, you must reanalyze your food safety plan (or the applicable portion of your food safety plan) to determine whether you need to modify your plan. See 21 CFR 507.42(b)(2)(v).

Finally, all corrective actions taken must be documented in records that are subject to verification and records review by (or under the oversight of) a PCQI. See 21 CFR 507.42(d).

5.7.2 Corrections

Corrections may be appropriate instead of corrective actions when minor, isolated problems occur that do not directly impact animal food safety. A "correction" is an action to identify and correct a problem that occurred during the production of animal food, without other actions associated with a corrective action procedure (such as actions to reduce the likelihood that the problem will recur, evaluate all affected animal food for safety, and prevent affected animal food from entering commerce). See 21 CFR 507.3. The term "correction" focuses on the first step in a corrective action procedure (i.e., identify and correct the problem).

For example, the following scenario illustrates when a correction may be appropriate instead of a corrective action. At production start-up, you observe pet food residue on cleaned equipment. Before using the equipment, you correct the pet food residue problem by re-cleaning and sanitizing the equipment. Because you correct the pet food residue problem before production, no pet food is affected, and no corrective actions are needed. You are not required to document this particular correction (see 21 CFR 507.42(d)).

If the correction was not made prior to production start-up, then you would need to follow your corrective action procedures because the sanitation preventive control was not properly implemented (see 21 CFR 507.42(a)(1)). In addition, if the problem is not isolated, such as you repeatedly find pet food residue on cleaned equipment, you would need to take corrective action to reduce the likelihood the problem will recur (see 21 CFR 507.42(b)(2)).

5.7.3 Corrective Action and Correction Records

You must document all corrective actions taken (and, when appropriate, corrections) in records that are subject to verification and records review. See 21 CFR 507.42(d). One way to comply with this requirement is to document the corrective action steps you have taken:

1. Document the actions taken to identify and correct the problem with implementation of the preventive control. For example, explain how you identified what went wrong with a process control and how you restored the process control.

2. Document what you did to reduce the likelihood that the problem will recur. Evaluation of historical corrective action records can help you identify recurring problems. When a deviation from a preventive control procedure recurs frequently and you find that the preventive control is ineffective, you must reanalyze the food safety plan (see 21 CFR 507.50(b)(4)).

3. Document how you evaluated the safety of all affected animal food. Depending on the nature of the deviation, you may need someone with specific technical expertise to conduct the evaluation.

4. Document what you did with any affected animal food, including identifying the specific animal food involved (e.g., lot numbers or batches, if applicable), the amount of animal food involved, and the disposition of the affected animal food (e.g., destroyed, reprocessed, or diverted to another use).

You are only required to document corrections in records when appropriate. See 21 CFR 507.42(d). However, we recommend documenting some corrections because they provide a record of both the problem and the steps you took to correct the problem. If the problem recurs on a frequent basis, such documentation also can be helpful in determining if a corrective action is needed (e.g., repairing or replacing equipment).

Boxes 5-4a and 5-4b provide examples of corrective actions.

Box 5-4a. PC Management Component Example – Corrective Actions

***Salmonella* in dog biscuit treats:** If your oven temperature drops below 352°F (178°C) (your operating limit), an alarm sounds. If the alarm sounds, the designated operator checks the oven to determine the problem and makes an adjustment if the problem is minor. If the temperature drops below 350°F (177°C) (i.e., deviates from your established minimum parameter value), incoming biscuits are stopped from entering the oven and biscuits within the oven are diverted and held to determine appropriate disposition. The designated operator immediately initiates a corrective action per your written corrective action procedures.

During production, an oven alarm sounds indicating that the oven temperature fell below 352°F (178°C). The designated operator conducts an initial inspection of the oven to see whether a minor adjustment will correct the temperature. While he is examining the oven, the temperature drops below 350°F (177°C) (the established minimum parameter value for temperature). Incoming biscuits are stopped from entering the oven, and biscuits within the oven are diverted and held to determine appropriate disposition. Per your written corrective action procedures, the designated operator promptly informs the shift manager, who oversees corrective actions. The shift manager then contacts the maintenance department. The maintenance individual determines the oven air recirculation fan was not operating properly and installs a new fan. The shift manager documents this repair in the corrective action records, along with her signature and date.

The shift manager also documents the lot number for the batch of biscuits that was in the oven when the oven temperature was below 350°F (177°C). All biscuits that were in the oven when the parameter value was not met are separated from other ingredients and products and set aside for destruction. To destroy the diverted biscuits, an employee puts the diverted biscuits in trash bags, adds a denaturing agent, and places the diverted biscuits in the dumpster. The shift manager observes the destruction and documents, in the corrective action record, the diverted biscuits' lot number.

Once the replacement parts are installed, the designated operator confirms that the oven temperature is at 355°F (179°C) prior to resuming production. To reduce the likelihood of a future preventive control failure, the maintenance department schedules more frequent checks to ensure that all parts of the oven are functioning properly.

Box 5-4b. PC Management Component Example – Corrective Actions

Monensin in horse food: Per your verification of monitoring procedures (see Box 5-5b), the plant manager conducts a review of sequencing and flushing records at the end of each day. One day he finds that a batch of horse food was manufactured directly after a batch of beef cattle food containing monensin. The plant manager is the individual assigned responsibility for identifying the cause of the improper implementation of the sequencing and flushing preventive control. The plant manager determines that failure to follow the established sequencing procedures is due to human error.

The plant manager records the lot code of the affected horse food and labels the container to identify that the batch must be kept from entering commerce until the affected horse food can be evaluated for safety. According to your corrective action procedures, when your sequencing plan is not properly executed you may either rework the batch of affected food for beef cattle or destroy the batch to ensure the food is not fed to susceptible animals (i.e., horses).

When you determine that the affected horse food is safe to be reworked for food for beef cattle, you reformulate the batch to be nutritionally adequate for beef cattle. You generate a rework record to document your corrective action that the affected horse food is being reworked and reformulated for beef cattle, and that the reworked horse food is safe for beef cattle.

To reduce the likelihood of a recurrence of the human error problem, all designated operators are immediately retrained on the sequencing and flushing preventive control procedures and their importance. This retraining is part of your corrective action and is documented in a record in your facility files.

5.8 Verification Activities

5.8.1 Verification

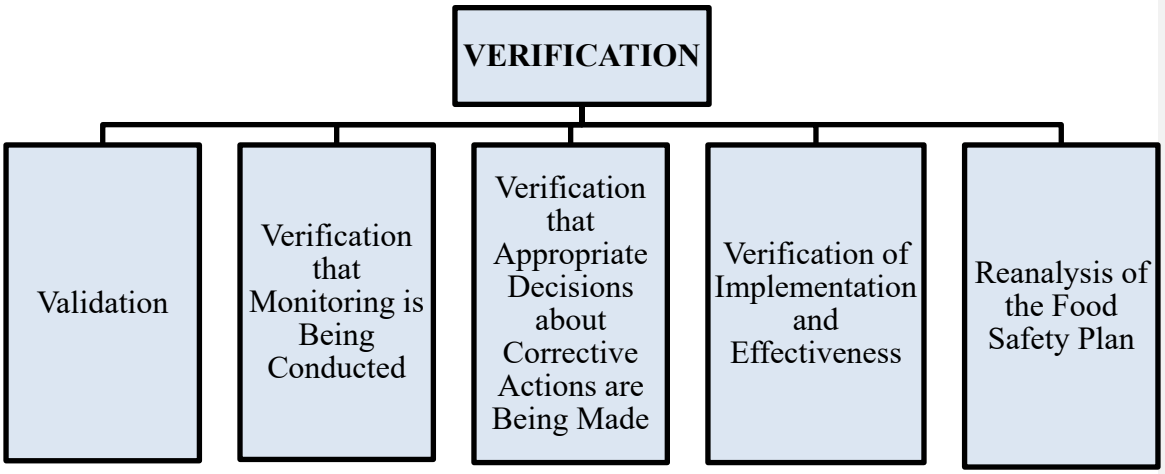
"Verification" means the application of methods, procedures, tests and other evaluations, in addition to monitoring, to determine whether a control measure or combination of control measures is or has been operating as intended and to establish the validity of the food safety plan (21 CFR 507.3). Verification answers the question: "Can I affirm that the preventive controls in my food safety plan are effective and being properly implemented to control the hazard(s)?"

To implement your preventive control, you are required to conduct several verification activities as appropriate to the nature of the preventive control and its role in your facility's food safety system. Your verification activities must be documented in records. See 21 CFR 507.45(b). A complete list of the verification activities is in 21 CFR 507.45, and summarized below and in Figure 5.1:

- validation in accordance with 21 CFR 507.47 – Validation

- verification that monitoring is being conducted in accordance with 21 CFR 507.40 – Monitoring
- verification that appropriate decisions about corrective actions are being made in accordance with 21 CFR 507.42 – Corrective Actions and Corrections
- verification of implementation and effectiveness of your preventive controls in accordance with 21 CFR 507.49 – Verification of Implementation and Effectiveness
- reanalysis of your food safety plan in accordance with 21 CFR 507.50 – Reanalysis

Figure 5-1. Verification Activities



5.8.2 Validation

"Validation" means obtaining and evaluating scientific and technical evidence that a control measure, combination of control measures, or the food safety plan as a whole, when properly implemented, is capable of effectively controlling the identified hazards (21 CFR 507.3). You must validate that the preventive controls you identify and implement are adequate to control the hazard as appropriate to the nature of the preventive control and the role of the preventive control in your facility's food safety system. See 21 CFR 507.47(a). In general, validation answers the question: "Can I provide scientific, technical, or study data evidence that my preventive control(s) can adequately control the hazard(s)?"

Validation is a verification activity that has its own requirements in 21 CFR 507.47. Validation must be performed or overseen by a PCQI (21 CFR 507.47(b)(1)).

Your PCQI must use or oversee the use of scientific and technical evidence to determine that the preventive controls you are implementing are adequate to control the biological, chemical, or physical hazards. See 21 CFR 507.47(b)(2). This evidence may come from various sources, such as peer-reviewed scientific articles, university extension whitepapers, government documents, predictive mathematical models and other risk-based models, and technical information from equipment manufacturers and trade associations. When using these resources

as evidence to validate your preventive controls, you should ensure that the evidence is applicable to your animal food and facility (e.g., processing equipment, manufacturing procedures, or storage conditions).

Sometimes, evidence may not exist; existing evidence is not applicable to your animal food and facility; or, the evidence is not sufficient to validate your preventive control. In these circumstances, you must conduct studies to determine that your preventive control, when properly implemented, is adequate to control the hazards. See 21 CFR 507.47(b)(2). We recommend that you consult with a food safety expert with knowledge of developing and conducting studies. The study must be conducted or overseen by a PCQI (21 CFR 507.47(b)(1)).

Validation must be documented in your records. See 21 CFR 507.45(b). You must retain records that document validation of your food safety plan for at least 2 years after their use is discontinued. See 21 CFR 507.208(b).

Validation must be completed within specific timeframes:

- prior to implementation of the food safety plan (see 21 CFR 507.47(b)(1)(i)(A))
- when necessary to demonstrate the preventive control can be implemented as designed:
    - within 90 calendar days after production of the applicable animal food first begins (21 CFR 507.47(b)(1)(i)(B)(1)), or
    - within a reasonable timeframe, provided that the PCQI prepares or oversees the preparation of a written justification for a timeframe that exceeds 90 calendar days after production of the applicable animal food first begins (21 CFR 507.47(b)(1)(i)(B)(2))
- whenever a change to a preventive control or combination of preventive controls could impact whether the preventive control or combination of preventive controls, when properly implemented, will effectively control the hazards (21 CFR 507.47(b)(1)(ii))
- whenever a reanalysis of the food safety plan reveals the need to do so (21 CFR 507.47(b)(1)(iii))

Although validation is appropriate for a variety of preventive controls, validation is not required for sanitation controls, your recall plan, the supply-chain program (in 21 CFR part 507, subpart E), and other preventive controls if a PCQI prepares a written justification that validation is not applicable (see 21 CFR 507.47(c)).

Boxes 5-5a and 5-5b provide examples of validation.

Box 5-5a. PC Management Component Example – Validation

***Salmonella* in dog biscuit treats:** Before you begin initial production of your dog biscuit treats, your PCQI searches peer-reviewed journals and extension white papers to find scientific literature on the time and temperature needed to significantly minimize *Salmonella* in dog biscuits. After evaluating the types of biscuits (including size, ingredients, and shape), processing equipment, and the manufacturing processes found in the literature review, your PCQI determines the time and temperature found in the literature (a minimum of 15 minutes at 350°F (177°C) or higher) are effective as a preventive control for *Salmonella* in biscuits baked at your facility. In order to ensure the safety of the dog biscuits, you bake your dog biscuits at 355°F (179°C). You maintain the scientific literature (i.e., evidence) your PCQI uses to validate the preventive control, and her determination that the preventive control is adequate to control the *Salmonella* hazard, as part of your facility's records.

Box 5-5b. PC Management Component Example – Validation

Monensin in horse food: Your PCQI obtains scientific literature and extension white papers to document the historical use by the animal food industry of sequencing and flushing procedures to prevent the occurrence of unsafe monensin levels in food for horses. Your PCQI evaluates the information and determines that the sequencing and flushing procedures described in the published literature and commonly practiced by the animal food industry can be appropriately implemented at your facility and will adequately control the hazard. You maintain, as part of your facility's records, the scientific literature (i.e., evidence) your PCQI uses to validate the preventive control and his determination that the preventive control is adequate.

5.8.3 Verification of Monitoring

You are required to verify that monitoring is being conducted in accordance with 21 CFR 507.40 (see 21 CFR 507.45(a)(2)). Verification relies, in part, on review of monitoring records to ensure that the preventive controls you have established are being implemented according to your food safety plan. Verification that monitoring is being conducted as required must be done in a way that is appropriate to the nature of the preventive control and its role in your facility's food safety system (see 21 CFR 507.45(a)(2)). You could determine, based on your preventive controls, that verification of monitoring can be accomplished by reviewing monitoring records, e.g., a review by a manager at the end of the operating day, or just the review by the PCQI required under 21 CFR 507.49(a)(4)(i). In addition, you may choose to actually observe the monitoring, e.g., a manager can periodically observe the equipment operator as the operator conducts the monitoring. Verification of monitoring must be documented in your records (see 21 CFR 507.45(b)).

Boxes 5-6a and 5-6b provide examples of verification of monitoring.

Box 5-6a. PC Management Component Example – Verification of Monitoring

***Salmonella* in dog biscuit treats:** Once during each shift, the shift manager checks the monitoring record for the oven temperature (the chart recorder printout and the record of the operator's check of the printout) and conveyor belt speed (the record of the operator's stopwatch timing results) to ensure the designated operator is monitoring at your specified frequency. At the end of each shift, the shift manager reviews the monitoring record and verifies that monitoring is being conducted according to your written procedures. The shift manager documents her verification of monitoring, including verification that there were no deviations from set parameter values, by initialing and dating a logbook kept with the oven monitoring records.

Box 5-6b. PC Management Component Example – Verification of Monitoring

Monensin in horse food: At the end of each day, the plant manager confirms that the sequencing production record for each batch of animal food (the 1st monitoring record) and the flushing record (the 2nd monitoring record) are generated and complete. He then compares the sequencing production records and flushing records to the written sequencing and flushing procedures. The plant manager signs and dates the monitoring records to show that he verified that the monitoring took place according to the sequencing and flushing procedures.

5.8.4 Verification of Decisions about Corrective Actions

You are required to verify that appropriate decisions about corrective actions are being made in accordance with 21 CFR 507.42 (see 21 CFR 507.45(a)(3)). The regulation allows flexibility for you to determine the activities you can use to verify that appropriate decisions were made about your corrective actions. You could determine, based on your preventive controls, that verification of decisions regarding corrective actions can be accomplished by reviewing corrective action records, e.g., a review by a manager after a corrective action, or just the review by the PCQI required under 21 CFR 507.49(a)(4)(i). In addition, you may choose to actually observe the corrective actions, e.g., a manager can observe the QI as he conducts the corrective action.

Boxes 5-7a and 5-7b provide examples of verification of decisions about corrective actions.

Box 5-7a. PC Management Component Example – Verification of Decisions about Corrective Actions

***Salmonella* in dog biscuit treats:** The shift manager verifies that appropriate decisions were made about corrective actions, confirming that the steps taken are consistent with your written corrective action procedures in your food safety plan. (See Box 5-11a for PCQI verification of corrective actions).

Box 5-7b. PC Management Component Example – Verification of Decisions about Corrective Actions

Monensin in horse food: The plant manager verifies that appropriate decisions were made about corrective actions, confirming that the steps taken are consistent with your written corrective action procedures in your food safety plan. (See Box 5-11b for PCQI verification of corrective actions).

5.8.5 Verification of Implementation and Effectiveness

You are required to verify that you are consistently implementing your preventive controls, and that your preventive controls are effective in significantly minimizing or preventing the hazard. See 21 CFR 507.49(a).

Various activities are required, as appropriate, to verify implementation and effectiveness of your preventive controls. Those activities must include, as appropriate to your facility, animal food, and the nature of the preventive control and its role in your facility's food safety system, calibration of instruments, product testing, environmental monitoring, and review of records. There may be additional activities you include based on your facility, animal food, and the nature of the preventive control and its role in your facility's food safety system. If you determine in your food safety plan that calibration of instruments, product testing, or environmental monitoring are appropriate for your facility, animal food, the nature of your preventive control, and the role of your preventive control in your facility's food safety system, then you must conduct these verification activities. See 21 CFR 507.49(a).

Calibration

You are required to calibrate, or check for accuracy, your instruments used for process monitoring and verification. See 21 CFR 507.49(a)(1). You must establish and implement written procedures for the method and frequency of the calibration (or accuracy check). See 21 CFR 507.49(b)(1).

By calibrate we mean compare to a standard, with adjustment to correct error as necessary. By accuracy check we mean simply comparison to a standard. An example of an accuracy check is using test weights to compare the weights shown on a small weight scale with the known weights of the test weights. Calibration as recommended by the instrument's manufacturer is important to ensure that the preventive control dependent on the instrument can be accurately monitored and verified. You may perform checks for accuracy on a more frequent basis than what is recommended by the instrument's manufacturer. If the outcome of the accuracy check shows your instrument is not accurate, we expect you to calibrate or replace the instrument.

When calibration or an accuracy check of a process monitoring or verification instrument shows that the instrument is not accurate, you should evaluate the monitoring records since the last instrument calibration or accuracy check to determine whether the inaccuracy would have contributed to a deviation. This deviation could indicate a failure of your preventive control,

meaning a corrective action is needed, including evaluation of the affected animal food. Food safety plans with infrequent calibration or accuracy checks can place more products at risk than those with more frequent checks if a problem with instrument accuracy occurs.

Boxes 5-8a and 5-8b provide examples of calibration, a component of verification of implementation and effectiveness.

Box 5-8a. PC Management Component Example – Verification of Implementation and Effectiveness, Calibration

> ***Salmonella* in dog biscuit treats:** Based on the recommendation of your PCQI, you use calibration of the thermocouple and conveyor speed as activities for verification of implementation and effectiveness of the time and temperature preventive control. The oven thermocouple is calibrated every six months based on the recommended maintenance schedule provided by the oven manufacturer. Thermocouple accuracy checks are conducted daily by comparing the readings to a separate temperature-indicating device. The separate temperature-indicating device is calibrated yearly. The conveyor speed also is calibrated every six months to coincide with the thermocouple calibration to ensure the retention time of the biscuit treats in the oven is accurate. You document in records all accuracy checks and calibrations for review by your PCQI. You have included written procedures for the method and frequency of calibration and accuracy checks in your written food safety plan.

Box 5-8b. PC Management Component Example – Verification of Implementation and Effectiveness, Calibration

> **Monensin in horse food:** Based on the recommendation of your PCQI, you use calibration of the weighing system to ensure an accurate amount of flushing material is added to the system as the activity for the verification of implementation and effectiveness of flushing as a preventive control in your facility. Your PCQI determines that an annual calibration is a sufficient frequency. You have included a written procedure for the method and frequency of calibration in your written food safety plan.

Product testing

In your facility, you may use product testing as a verification of implementation and effectiveness of your preventive controls. Product testing is often considered an effective way to verify the control of a biological hazard. Also, you may use product testing to verify the control of other hazards, such as nutrient deficiencies or toxicities. Product testing is not required for all facilities that identify pathogens or other hazards requiring a preventive control. While product testing is a way to verify the implementation and effectiveness of your preventive controls for the purposes of 21 CFR 507.49, product testing does not prevent or significantly minimize the hazard. Therefore, product testing is not a preventive control.

If you use product testing to verify that your preventive control is consistently implemented and effective, you must establish and implement written procedures for the product testing. See 21

CFR 507.49(b). The following requirements in 21 CFR 507.49(b)(2) apply to the procedures for product testing. The procedures must:

- be scientifically valid
- identify the test microorganisms or other analytes
- specify the procedures for identifying samples, including their relationship to specific lots of product
- include the procedures for sampling, including the number of samples and sampling frequency
- identify the tests conducted including the analytical methods used
- identify the laboratory conducting the testing
- include the corrective action procedures required by 21 CFR 507.42(a)(1)

Boxes 5-9a and 5-9b provide examples of product testing, a component of verification of implementation and effectiveness of preventive controls.

Box 5-9a. PC Management Component Example – Verification of Implementation and Effectiveness, Product Testing

> ***Salmonella* in dog biscuit treats:** Your PCQI determines that product testing for *Salmonella* is an appropriate activity for verification of implementation and effectiveness of your time and temperature preventive control. Your written procedures specify that once a week, a sample will be randomly collected from each batch during the selected shift (which alternates each week). Each sample of biscuits collected consists of 10 sub-samples with each sub-sample weighing about 200 grams and labeled with the corresponding batch number(s). The samples are analyzed in-house using a validated method from the most recent edition of the *Bacteriological Analytical Manual*, chapter 5. If a laboratory sample is found to contain *Salmonella*, your shift manager follows corrective action procedures found in your food safety plan to address the presence of a pathogen detected upon product testing.

Box 5-9b. PC Management Component Example – Verification of Implementation and Effectiveness, Product Testing

> **Monensin in horse food:** The PCQI did not identify product testing as an activity for verification of implementation and effectiveness for your sequencing and flushing preventive control.

Environmental monitoring

Environmental monitoring, for an environmental pathogen or for an appropriate indicator organism, may be used when your hazard analysis determines that contamination of animal food with an environmental pathogen (or appropriate indicator organism) is a hazard requiring a

preventive control. You determine (based on your facility, your animal food, and the nature of the preventive control and its role in your facility's food safety system) if environmental monitoring is appropriate to verify the adequacy of your preventive control. For example, you could decide that environmental monitoring is necessary to verify that your sanitation controls are implemented properly and working effectively to control *Salmonella* in the environment.

The presence of an indicator organism indicates conditions may be suitable for the presence and growth of an environmental pathogen. FDA's current thinking is that *Listeria* spp. may be an appropriate indicator organism for *L. monocytogenes,* because tests for *Listeria* spp. will detect multiple species of *Listeria*, including *L. monocytogenes*. Though data are available to support the use of Enterobacteriaceae for environmental monitoring, we are not aware of any data or information supporting the use of an indicator organism by itself for the purpose of environmental monitoring for *Salmonella* spp. (Ref. 1).

If you use environmental monitoring to verify that your preventive controls are consistently implemented and effective, you must establish and implement written procedures for the environmental monitoring. See 21 CFR 507.49(b). The following requirements in 21 CFR 507.49(b)(3) apply to the procedures for environmental monitoring. The procedures must:

- be scientifically valid
- identify the test microorganisms
- identify the locations from which samples will be collected and the number of sites to be tested during routine environmental monitoring (the number and location of sampling sites must be adequate to determine whether preventive controls are effective)
- identify the timing and frequency for collecting and testing samples (the timing and frequency for collecting and testing samples must be adequate to determine whether preventive controls are effective)
- identify the tests conducted, including the analytical methods used
- identify the laboratory conducting the testing
- include the corrective action procedures required by 21 CFR 507.42(a)(1)(ii)

Environmental monitoring involves collecting samples for environmental pathogen analysis from areas in your facility where animal food is manufactured, processed, packed or held. You determine where and how often environmental samples are taken in your facility and include this in your written procedures. An effective environmental monitoring program diligently tries to find the pathogen. To be effective, the sampling is conducted with sufficient frequency and samples are taken in places in the facility where the pathogen is likely found, such as areas that may have been contaminated with raw animal food ingredients, or areas that are frequently wet. For additional information on environmental monitoring see (Ref. 2).

Boxes 5-10a and 5-10b provide examples of decisions about environmental monitoring, a component of verification of implementation and effectiveness of preventive controls.

Box 5-10a. PC Management Component Example – Verification of Implementation and Effectiveness, Environmental Monitoring

> ***Salmonella* in dog biscuit treats:** The PCQI did not identify environmental monitoring as a verification of implementation and effectiveness activity for your time and temperature preventive control since the dog biscuits are not exposed to the environment prior to packaging.

Box 5-10b. PC Management Component Example – Verification of Implementation and Effectiveness, Environmental Monitoring

> **Monensin in horse food:** The PCQI did not identify environmental monitoring as a verification of implementation and effectiveness activity for your sequencing and flushing preventive control.

Record review

Verification of implementation and effectiveness includes the review of certain records within specified timeframes. This review must be conducted by, or under the oversight of, a PCQI (see 21 CFR 507.49(a)(4)). Monitoring and corrective action records must be reviewed within seven working days after the records are created or within a reasonable timeframe, provided the PCQI prepares (or oversees the preparation of) a written justification for a timeframe that exceeds seven working days. See 21 CFR 507.49(a)(4)(i). Records of calibration, product testing, environmental monitoring, supplier and supply-chain verification activities, and other verification activities must be reviewed within a reasonable timeframe after they are created. See 21 CFR 507.49(a)(4)(ii).

Record review by, or under the oversight of, a PCQI must ensure the following:

- records are complete
- activities reflected in the records occurred in accordance with the food safety plan
- preventive controls are effective
- appropriate decisions were made about corrective actions

See 21 CFR 507.49(a)(4).

Record review conducted in accordance with 21 CFR 507.49 must be documented in records (see 21 CFR 507.45(b)).

Boxes 5-11a and 5-11b provide examples of record review, a component of verification of implementation and effectiveness.

Box 5-11a. PC Management Component Example – Verification of Implementation and Effectiveness, Record Review

***Salmonella* in dog biscuit treats:** You determine that the monitoring records (your temperature chart recorder printout and record of the operator's check of the printout and conveyor speed record) will be verified at the end of each shift by the shift manager (see Box 5-6a). Your plant manager will conduct a review of the monitoring records every Monday. Since the shift manager is reviewing monitoring records at the end of each shift, and the plant manager is reviewing weekly, your PCQI writes a justification that she only needs to review the monitoring records once a month. During her monthly review, your PCQI signs that she verified the monitoring records.

Within one week after the calibration is performed (see Box 5-8a), your PCQI reviews the calibration records of the oven thermocouple, temperature indicating device, and conveyor speed to complete record review for verification of implementation and effectiveness of the time and temperature preventive control. The PCQI reviews the daily thermocouple accuracy check during her monthly review of the monitoring records. She documents her review of the calibration and accuracy check records at the time she performs these verification activities.

When a corrective action is taken, your corrective action procedures require the PCQI to review associated records within five working days. Your PCQI reviews the corrective action records generated after the failure of your time and temperature preventive control (see Box 5-4a). The corrective action records she reviews are:

1. the temperature chart recorder record that identified the problem
2. documentation of the lot number of the diverted biscuits
3. diverted biscuit destruction record
4. oven repair record
5. maintenance schedule update

Through the corrective action record review, she also ensures that the outcome of the safety evaluation, destruction of the biscuits, and increase in the oven maintenance schedule were appropriate decisions for this corrective action.

Once the corrective action records are reviewed and the PCQI determines that appropriate decisions were made about the corrective action, your PCQI signs the records and places them in the corrective action file.

Box 5-11b. PC Management Component Example – Verification of Implementation and Effectiveness, Record Review

Monensin in horse food: Your facility determines that the two monitoring records (sequencing production record and flushing record) will be verified daily by the plant manager (see Boxes 5-3b and 5-6b) and reviewed weekly by the PCQI. Your PCQI reviews and signs the two monitoring records.

Your PCQI reviews the annual calibration record of the weighing system within one week after the weighing system is calibrated (see Box 5-8b).

When a corrective action is taken, your facility's procedures require your PCQI to review associated records within seven working days. During the weekly record review, your PCQI reviews the corrective action records generated after the failure of your sequencing and flushing preventive control (see Box 5-4b). He ensures the following records are complete and consistent with your corrective action procedures for the sequencing and flushing preventive control:

1. the sequencing and flushing records that identified the problem
2. documentation of the lot number of the affected horse food
3. rework record
4. employee retraining record

Through the corrective action record review, he also ensures that the outcome of the safety evaluation, rework of the horse food for beef cattle food, and retraining of the designated operators are appropriate decisions for this corrective action.

Once the corrective action records are reviewed and the PCQI determines appropriate decisions were made about the corrective action, your PCQI signs the records and places them in the corrective action file.

5.8.6 Reanalysis

You must conduct a reanalysis of your food safety plan (see 21 CFR 507.50). Reanalysis is a verification activity and must be documented (see 21 CFR 507.45(b)). Your required reanalysis must be conducted by, or overseen by, your PCQI (see 21 CFR 507.50(e)).

At least once every 3 years, you must conduct a reanalysis of your food safety plan as a whole. See 21 CFR 507.50(a). A reanalysis of the plan or the applicable portion of the plan is also required whenever:

- a significant change in the activities conducted at your facility creates a reasonable potential for a new hazard or creates a significant increase in a previously identified hazard (see 21 CFR 507.50(b)(1))
- you become aware of new information about potential hazards associated with the animal food (see 21 CFR 507.50(b)(2))

- appropriate after an unanticipated animal food safety problem (see 21 CFR 507.50(b)(3))
- you find that a preventive control, combination of preventive controls, or the food safety plan as a whole is ineffective (see 21 CFR 507.50(b)(4))
- FDA determines a reanalysis is necessary to respond to new hazards and developments in scientific understanding (see 21 CFR 507.50(f))

The need for a reanalysis of your food safety plan sooner than 3 years (i.e., a for-cause reanalysis) will vary by facility and animal food and on a case-by-case basis. We recommend you consult your PCQI about when to conduct a for-cause reanalysis. Depending on the cause for the reanalysis, you may need to reanalyze your whole food safety plan, or just the applicable portion of your food safety plan (see 21 CFR 507.50(b)).

The following are examples of some circumstances that would or would not require a for-cause reanalysis of your food safety plan, or an applicable portion of your food safety plan.

Significant change in activities conducted at your facility that creates a reasonable potential for a new hazard or creates a significant increase in a previously identified hazard (see 21 CFR 507.50(b)(1)):

- You currently manufacture food for cattle and swine but are expanding your operation to start manufacturing poultry food. You reanalyze your food safety plan to include poultry food. Your hazard analysis may determine that there are additional hazards requiring a preventive control. If so, you would revise your preventive controls and management components to control these hazards.

- You start using a different corn by-product as an ingredient in your animal food. Your hazard analysis already considers the known or reasonably foreseeable hazards associated with using corn and corn by-products in your animal food. You do not need to reanalyze your food safety plan because the hazards associated with using corn by-products are already covered in your hazard analysis and the new ingredient does not create a significant increase in the identified hazards.

You become aware of new information about potential hazards associated with the animal food (see 21 CFR 507.50(b)(2)):

- At the conclusion of an inspection, you receive a Form FDA 483, Inspectional Observations, observing that your facility uses corn as an ingredient, and you have not identified aflatoxin as a known or reasonably foreseeable hazard in your hazard analysis. You would reanalyze the applicable portion(s) of your food safety plan, including performing an evaluation of aflatoxin as a known or reasonably foreseeable hazard associated with the use of corn as an ingredient.

- You manufacture food for horses and in reading a trade magazine learn that horses are very sensitive to monensin. Your facility does not manufacture medicated feed. As a

result, you would not reanalyze your food safety plan because monensin is not used in your facility.

Unanticipated animal food safety problem (see 21 CFR 507.50(b)(3)):

- You manufacture cattle food and horse food. Your current food safety plan identifies non-protein nitrogen (NPN) nutrient toxicity from urea as a known or reasonably foreseeable hazard in your cattle food because you use urea in your cattle food. But you had determined that NPN toxicity was not a hazard requiring a preventive control because your batching and mixing procedures have historically resulted in appropriate amounts of urea in your cattle food. You did not identify NPN toxicity as a known or reasonably foreseeable hazard in your horse food because urea is not used as an ingredient in horse food. Later, you receive several complaints about NPN toxicity in horses consuming your horse food and you initiate a recall. You perform an investigation and find the urea was added to horse food due to employee error. Because of the unanticipated animal food safety problem (nutrient toxicity from urea), you reanalyze your food safety plan to consider NPN toxicity for your horse food.

- You initiate a market withdrawal of your packaged animal food because your printer malfunctioned and as a result, your package label does not include the required net quantity of contents as outlined in 21 CFR 501.105. You would not reanalyze your food safety plan as a result of this market withdrawal. You initiated the market withdrawal to address a misbranding issue; however, the market withdrawal is not related to a food safety issue.

You find that your preventive control, combination of preventive controls, or the food safety plan as a whole is ineffective (see 21 CFR 507.50(b)(4)):

- You manufacture dog food and, based on your hazard evaluation, conclude that the probability of a vitamin D toxicity occurring is low at your facility due to your existing prerequisite programs. As a result, you determine vitamin D toxicity is not a hazard requiring a preventive control. You later receive consumer complaints with accompanying veterinary records indicating possible vitamin D toxicity in dogs. You do a root cause investigation and determine your prerequisite programs were not followed, which resulted in finished dog food with toxic levels of vitamin D. Because your food safety plan as a whole was ineffective, you reanalyze your food safety plan to reconsider the vitamin D toxicity hazard.

- You receive a complaint from one customer who suspects that the chicken food they received for laying hens was deficient in calcium. You request the customer provide a sample of the food. You have their sample and a portion of your retained food for that lot analyzed for calcium. The analysis results show that each sample was in the range appropriate for laying hens. You would not need to reanalyze your food safety plan.

You must complete reanalysis of your food safety plan and validate any additional preventive controls: (1) before any change in activity is in effect; or, (2) when necessary to demonstrate the

control measure can be implemented as designed, within 90 calendar days after production of animal food begins, or within a reasonable timeframe that exceeds 90 days as outlined in a written justification from your PCQI. See 21 CFR 507.50(c).

If a significant change in the activities conducted at your facility creates a reasonable potential for a new hazard or creates a significant increase in a previously identified hazard, you must revise your food safety plan or document the basis for your conclusion that no revisions are needed. See 21 CFR 507.50(d).

The documentation of reanalysis must include the date the reanalysis was conducted and the signature or initials of the individual conducting the reanalysis. See 21 CFR 507.202(b)(2) and (3).

Boxes 5-12a and 5-12b provide examples of reanalysis.

Box 5-12a. PC Management Component Example – Reanalysis

> ***Salmonella* in dog biscuit treats:** The oven fan was replaced with the same model fan, confirmed to be operating properly by the designated operator, and there is no change in the process. Your PCQI determines that a reanalysis of the food safety plan for the preventive control of *Salmonella* in your dog biscuit treats is not necessary.
>
> You decide to install an additional production line to make miniature size dog biscuit treats. This is a significant change in your production that creates a significant increase in the *Salmonella* hazard, which requires a reanalysis of your food safety plan. Prior to beginning production of the miniature biscuits, your PCQI validates the time and temperature preventive control required to significantly minimize *Salmonella* in the smaller size biscuit. The new preventive control, procedures for monitoring the preventive control, and corrective action procedures are added to your revised food safety plan.

Box 5-12b. PC Management Component Example – Reanalysis

> **Monensin in horse food:** Your PCQI determines that a reanalysis of the food safety plan is appropriate because it has been three years since the last reanalysis. Your PCQI conducts the reanalysis and concludes that no changes are needed for the sequencing and flushing preventive control.

5.9 References for Chapter 5

1. Food and Drug Administration. 2014. “FDA Memorandum Environmental Monitoring”.

APPENDIX A – Glossary of Terms

Definitions Established in 21 CFR 507.3:

Adequate means that which is needed to accomplish the intended purpose in keeping with good public (human and animal) health practice.

Animal food means food for animals other than man and includes pet food, animal feed, and raw materials and ingredients.

Correction means an action to identify and correct a problem that occurred during the production of animal food, without other actions associated with a corrective action procedure (such as actions to reduce the likelihood that the problem will recur, evaluate all affected animal food for safety, and prevent affected animal food from entering commerce).

Critical control point means a point, step, or procedure in a food process at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce such hazard to an acceptable level.

Environmental pathogen means a pathogen capable of surviving and persisting within the manufacturing, processing, packing, or holding environment such that food for animals may be contaminated and may result in foodborne illness if that animal food is not treated to significantly minimize or prevent the environmental pathogen. Examples of environmental pathogens for the purposes of this part include *Listeria monocytogenes* and *Salmonella* spp. But do not include the spores of pathogenic spore-forming bacteria.

Facility means a domestic facility or a foreign facility that is required to register under section 415 of the Federal Food, Drug, and Cosmetic Act, in accordance with the requirements of 21 CFR part 1, subpart H.

Farm means farm as defined in 21 CFR 1.227.

Food-contact surfaces are those surfaces that contact animal food and those surfaces from which drainage, or other transfer, onto the animal food or onto surfaces that contact the animal food ordinarily occurs during the normal course of operations. "Food-contact surfaces" includes utensils and animal food-contact surfaces of equipment.

Hazard means any biological, chemical (including radiological), or physical agent that has the potential to cause illness or injury in humans or animals.

Hazard requiring a preventive control means a known or reasonably foreseeable hazard for which a person knowledgeable about the safe manufacturing, processing, packing, or holding of animal food would, based on the outcome of a hazard analysis (which includes an assessment of the severity of the illness or injury to humans or animals if the hazard were to occur and the probability that the hazard will occur in the absence of preventive controls), establish one or more preventive controls to significantly minimize or prevent the hazard in an animal food and

components to manage those controls (such as monitoring, corrections or corrective actions, verification, and records) as appropriate to the animal food, the facility, and the nature of the preventive control and its role in the facility's food safety system.

Holding means storage of animal food and also includes activities performed incidental to storage of an animal food (e.g., activities performed for the safe or effective storage of that animal food, such as fumigating animal food during storage, and drying/dehydrating raw agricultural commodities when the drying/dehydrating does not create a distinct commodity (such as drying/dehydrating hay or alfalfa)). Holding also includes activities performed as a practical necessity for the distribution of that animal food (such as blending of the same raw agricultural commodity and breaking down pallets), but does not include activities that transform a raw agricultural commodity into a processed food as defined in section 201(gg) of the Federal Food, Drug, and Cosmetic Act. Holding facilities could include warehouses, cold storage facilities, storage silos, grain elevators, and liquid-storage tanks.

Known or reasonably foreseeable hazard means a biological, chemical (including radiological), or physical hazard that is known to be, or has the potential to be, associated with the facility or the animal food.

Lot means the animal food produced during a period of time and identified by an establishment's specific code.

Manufacturing/processing means making animal food from one or more ingredients, or synthesizing, preparing, treating, modifying, or manipulating animal food, including food crops or ingredients. Examples of manufacturing/processing activities include: Baking, boiling, bottling, canning, cooking, cooling, cutting, distilling, drying/dehydrating raw agricultural commodities to create a distinct commodity (such as drying/dehydrating grapes to produce raisins), evaporating, eviscerating, extracting juice, extruding, formulating, freezing, grinding, homogenizing, irradiating, labeling, milling, mixing, packaging (including modified atmosphere packaging), pasteurizing, peeling, pelleting, rendering, treating to manipulate ripening, trimming, washing, or waxing. For farms and farm mixed-type facilities, manufacturing/processing does not include activities that are part of harvesting, packing, or holding.

Microorganisms means yeasts, molds, bacteria, viruses, protozoa, and microscopic parasites and includes species that are pathogens. The term "undesirable microorganisms" includes those microorganisms that are pathogens, that subject animal food to decomposition, that indicate that animal food is contaminated with filth, or that otherwise may cause animal food to be adulterated.

Monitor means to conduct a planned sequence of observations or measurements to assess whether control measures are operating as intended.

Packing means placing animal food into a container other than packaging the animal food and also includes repacking and activities performed incidental to packing or repacking an animal food (e.g., activities performed for the safe or effective packing or repacking of that animal food (such as sorting, culling, grading, and weighing or conveying incidental to packing or

repacking)), but does not include activities that transform a raw agricultural commodity into a processed food as defined in section 201(gg) of the Federal Food, Drug, and Cosmetic Act.

Pathogen means a microorganism of public (human or animal) health significance.

Pest refers to any objectionable animals or insects including birds, rodents, flies, and larvae.

Plant means the building or structure, or parts thereof, used for or in connection with the manufacturing, processing, packing, or holding of animal food.

Preventive controls means those risk-based, reasonably appropriate procedures, practices, and processes that a person knowledgeable about the safe manufacturing, processing, packing, or holding of animal food would employ to significantly minimize or prevent the hazards identified under the hazard analysis that are consistent with the current scientific understanding of safe food manufacturing, processing, packing, or holding at the time of the analysis.

Preventive controls qualified individual means a qualified individual who has successfully completed training in the development and application of risk-based preventive controls at least equivalent to that received under a standardized curriculum recognized as adequate by FDA, or is otherwise qualified through job experience to develop and apply a food safety system.

Qualified individual means a person who has the education, training, or experience (or a combination thereof) necessary to manufacture, process, pack, or hold safe animal food as appropriate to the individual's assigned duties. A qualified individual may be, but is not required to be, an employee of the establishment.

Raw agricultural commodity has the meaning given in section 201(r) of the Federal Food, Drug, and Cosmetic Act.

Receiving facility means a facility that is subject to subparts C and E of this part [part 507] and that manufactures/processes a raw material or other ingredient that it receives from a supplier.

Rework means clean, unadulterated animal food that has been removed from processing for reasons other than insanitary conditions or that has been successfully reconditioned by reprocessing and that is suitable for use as animal food.

Sanitize means to adequately treat cleaned surfaces by a process that is effective in destroying vegetative cells of pathogens, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the product or its safety for animals or humans.

Significantly minimize means to reduce to an acceptable level, including to eliminate.

Supplier means the establishment that manufactures/processes the animal food, raises the animal, or grows the food that is provided to a receiving facility without further manufacturing/ processing by another establishment, except for further manufacturing/ processing that consists solely of the addition of labeling or similar activity of a *de minimis* nature.

Supply-chain-applied control means a preventive control for a hazard in a raw material or other ingredient when the hazard in the raw material or other ingredient is controlled before its receipt.

Unexposed packaged animal food means packaged animal food that is not exposed to the environment.

Validation means obtaining and evaluating scientific and technical evidence that a control measure, combination of control measures, or the food safety plan as a whole, when properly implemented, is capable of effectively controlling the identified hazards.

Verification means the application of methods, procedures, tests and other evaluations, in addition to monitoring, to determine whether a control measure or combination of control measures is or has been operating as intended and to establish the validity of the food safety plan.

Water activity (a_w) means a measure of the free moisture in an animal food and is the quotient of the water vapor pressure of the substance divided by the vapor pressure of pure water at the same temperature.

You means, for purposes of 21 CFR part 507, the owner, operator, or agent in charge of a facility.

Other Terms Used in this Guidance:

Clean in place (CIP): A system used to clean process piping, bins, tanks, mixing equipment, or larger pieces of equipment without disassembly, where interior product zones are fully exposed and soil can be readily washed away by the flow of the cleaning solution.

Cleaning: The removal of soil, animal food residue, dirt, grease or other objectionable matter.

Corrective action: An action to identify and correct specific problems, including failure to properly implement a preventive control, that occur during the production of animal food.

A corrective action must include certain elements, such as identification and correction of the problem, reducing the likelihood of recurrence, evaluating the animal food for safety, and preventing adulterated animal food from entering commerce. The requirements for corrective actions are found in 21 CFR 507.42(a) and (b).

Deviation: Failure to meet a parameter value (e.g., by being above or below the parameter value).

Environmental sample: A sample that is collected from a surface or area of the plant for the purpose of testing the surface or area for the presence of an environmental pathogen or appropriate indicator organism.

HACCP (Hazard Analysis and Critical Control Point): A systematic approach to the identification, evaluation, and control of food safety hazards.

Hazard analysis: The process of identifying and evaluating known or reasonably foreseeable hazards to determine whether there are any hazards requiring a preventive control.

Operating limits: Criteria that may be more stringent than the minimum or maximum parameter values and are established for reasons other than animal food safety.

Parameter value: The maximum or minimum value, or combination of values, to which any biological, chemical, or physical parameter must be controlled to significantly minimize or prevent a hazard requiring a process control.

PCAF regulation: Part 507 of title 21 of the Code of Federal Regulations, established by the final rule entitled "Current Good Manufacturing Practice, Hazard Analysis, and Risk-Based Preventive Controls for Food for Animals".

PCAF requirements: The requirements of subparts A, C, D, E, and F of part 507 of Title 21 of the Code of Federal Regulations.

APPENDIX B – Table of Abbreviations and Acronyms Used in this Guidance

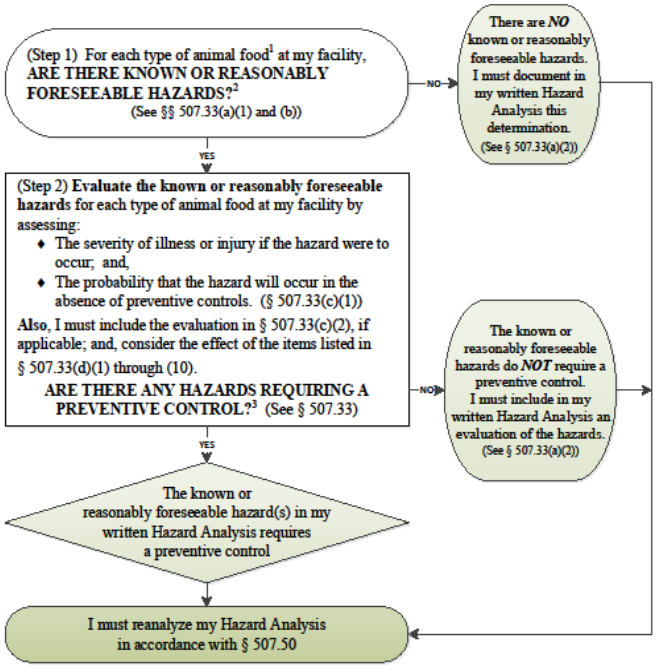
ABBREVIATION OR ACRONYM	WHAT IT MEANS
AAFCO	Association of American Feed Control Officials
a_w	water activity
BSE	Bovine Spongiform Encephalopathy
C. botulinum	*Clostridium botulinum*
CCP	critical control point
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CGMP	current good manufacturing practice
CGMP requirements	current good manufacturing practice requirements in 21 CFR part 507, subparts A, B, and F
CIP	clean in place
Codex	Codex Alimentarius Commission
CWD	Chronic Wasting Disease
D-value	decimal reduction time
DNA	deoxyribonucleic acid
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
ERH	equilibrium relative humidity
eV	electron volt
FDA	U.S. Food and Drug Administration

ABBREVIATION OR ACRONYM	WHAT IT MEANS
FD&C Act	Federal Food, Drug, and Cosmetic Act
FSIS	Food Safety and Inspection Service of the U.S. Department of Agriculture
FSMA	FDA Food Safety Modernization Act
FSPCA	Food Safety Preventive Controls Alliance
GRAS	generally recognized as safe
Gy	Gray (a unit of absorbed dose of ionizing radiation, equal to 1 joule/kg of irradiated material)
HACCP	Hazard Analysis and Critical Control Point
HA worksheet	Hazard Analysis worksheet
HPP	high pressure processing
kGy	kiloGray
Kg	kilogram
LACF	low-acid canned food
L. monocytogenes	*Listeria monocytogenes*
MBM	meat and bone meal
MeV	million electron volts
mm	millimeter
MPa	megapascal
ng	nanogram
NRC	National Research Council

ABBREVIATION OR ACRONYM	WHAT IT MEANS
Pa	pascal
PAH	polyaromatic hydrocarbon
PCAF regulation	Current Good Manufacturing Practice, Hazard Analysis, and Risk-Based Preventive Controls for Food for Animals regulation in 21 CFR part 507
PCB	polychlorinated biphenyl
PC management components	preventive control management components
PCQI	preventive controls qualified individual
PC requirements	Preventive control requirements in 21 CFR part 507, subparts A, C, D, E, and F
pH	refers to a numeric scale used to describe acidity and alkalinity
ppb	parts per billion
QI	qualified individual
RFR	Reportable Food Registry
ROP	reduced oxygen packaging
SOP	standard operating procedure
TDT	thermal death time
T. *gondii*	*Toxoplasma gondii*
USDA	U.S. Department of Agriculture
z-value	refers to the temperature increase required to reduce the D-value by a factor of 10

APPENDIX C – Flowchart – Hazard Analysis (21 CFR 507.33)

My facility is subject to the hazard analysis and preventive controls requirements. My required **written** Food Safety Plan must be prepared by a preventive controls qualified individual and include a **written** Hazard Analysis.



1. *Animal food* means food for animals other than man and includes pet food, animal feed, and raw materials and ingredients (21 CFR 507.3).
2. *Hazard* means any biological, chemical (including radiological), or physical agent that has the potential to cause illness or injury in humans or animals (21 CFR 507.3).
Known or reasonably foreseeable hazard means a biological, chemical (including radiological), or physical hazard that is known to be, or has the potential to be, associated with the facility or the animal food (21 CFR 507.3).
3. *Hazard requiring a preventive control* means a known or reasonably foreseeable hazard for which a person knowledgeable about the safe manufacturing, processing, packing, or holding of animal food would, based on the outcome of a hazard analysis (which includes an assessment of the severity of the illness or injury to humans or animals if the hazard were to occur and the probability that the hazard will occur in the absence of preventive controls), establish one or more preventive controls to significantly minimize or prevent the hazard in an animal food and components to manage those controls (such as monitoring, corrections or corrective actions, verification, and records) as appropriate to the animal food, the facility, and the nature of the preventive control and its role in the facility's food safety system (21 CFR 507.3).

APPENDIX C – Hazard Analysis (21 CFR 507.33)

My facility is subject to the hazard analysis and preventive controls requirements. My required written Food Safety Plan must be prepared by, or under the oversight of, a preventive controls qualified individual and include a written Hazard Analysis.

Step 1 – FOR EACH TYPE OF ANIMAL FOOD AT MY FACILITY, **ARE THERE KNOWN OR REASONABLY FORESEEABLE HAZARDS**? See 21 CFR 507.33(a)(1) and (b).

NO – There are NO known or reasonably foreseeable hazards. I must document in my written Hazard Analysis this determination. See 21 CFR 507.33(a)(2). I must reanalyze my Hazard Analysis in accordance with 21 CFR 507.50.

YES – **Step 2 –** Evaluate the known or reasonably foreseeable hazards for each type of animal food at my facility by assessing:

- The severity of illness or injury if the hazard were to occur; and,
- The probability that the hazard will occur in the absence of preventive controls. (21 CFR 507.33(c)(1))

Also, I must include the evaluation in 21 CFR 507.33(c)(2), if applicable; and, consider the effect of the items listed in 21 CFR 507.33(d)(1) through (10) on the safety of the finished animal food for the intended animal.

ARE THERE ANY HAZARDS REQUIRING A PREVENTIVE CONTROL?
See 21 CFR 507.33.

NO – The known or reasonably foreseeable hazards do NOT require a preventive control. I must include in my written Hazard Analysis an evaluation of the hazards. See 21 CFR 507.33(a)(2). I must reanalyze my Hazard Analysis in accordance with 21 CFR 507.50.

YES – The known or reasonably foreseeable hazard(s) in my written Hazard Analysis requires a preventive control. I must reanalyze my Hazard Analysis in accordance with 21 CFR 507.50. (I must also identify and implement preventive controls and appropriate preventive control management components in accordance with 21 CFR 507.34 and 507.39).

APPENDIX D – Example Hazard Analysis Worksheet

The example Hazard Analysis worksheet is organized by column. Chapters 2 and 3 provide information that can be used to complete columns one through four. Chapter 4 provides information that can be used to complete columns five and six.

Note: A typical worksheet may include multiple pages. Also, you may need to attach additional information or documentation, such as when you determine that a hazard does not require a preventive control. You may use any method that results in a written hazard analysis. The FSPCA curriculum for animal food provides another example of a hazard analysis worksheet.

PLANT NAME: _____

ADDRESS: _____

ANIMAL FOOD: _____

INTENDED SPECIES: _____

LIFE STAGE/PRODUCTION CLASS: _____

DATE (MM/DD/YY): _____

(Column 1) Ingredient and Processing Step	(Column 2) Known or Reasonably Foreseeable Hazard	(Column 3) Does the Known or Reasonably Foreseeable Hazard Require a Preventive Control? "Yes" or "No"	(Column 4) Explanation/ Justification	(Column 5) Preventive Control(s) Applied	(Column 6) Is the Preventive Control Applied at this Step? "Yes" or "No"

APPENDIX D

How to Use the Hazard Analysis Worksheet

Column 1 – Ingredient and Processing Step: List: (1) the receipt of ingredients used in your process as a way of identifying hazards associated with an ingredient (you may group similar ingredients such as grains); and (2) the processing steps. A process flow diagram and detailed process description (**see Chapter 2, Box 2-2**) can help you identify the processing steps included in your hazard analysis.

Column 2 – Known or Reasonably Foreseeable Hazard: List the results of your identification of the known or reasonably foreseeable hazards from your hazard analysis. Include biological, chemical, or physical hazards that could be introduced or increased from ingredients, your process, or the environment. **See Chapter 2, section 2.4.1.**

Column 3 – Does the Known or Reasonably Foreseeable Hazard Require a Preventive Control: For each known or reasonably foreseeable hazard identified in column 2, record the conclusions of your hazard analysis – i.e., the determinations you make whether each known or reasonably foreseeable hazard requires a preventive control ("Yes" or "No"). **See Chapter 2, section 2.4.2.**

Column 4 – Explanation/Justification: You should justify, or explain, your "Yes" or "No" conclusion for column 3 based on your evaluation of the hazard. Record the key factors or a summary of the evaluation that led to the determination for each hazard of whether a preventive control is required. Explaining your reasons for a "No" conclusion can be just as important as explaining your reasons for a "Yes" conclusion. **See Chapter 2, section 2.5.**

Column 5 – Preventive Control(s) Applied: Identify the preventive control(s) you will apply to significantly minimize or prevent the hazard requiring a preventive control (indicated by "Yes" in column 3). You might list, for example, the type of preventive control (e.g., process, sanitation, or supply-chain-applied controls), or list the specific preventive control you select (e.g., irradiation, time and temperature, or a_w). **See Chapter 2, section 2.6, and Chapter 4.**

If the identified hazard does not require a preventive control (indicated by "No" in column 3), you can leave the corresponding cell blank or put in N/A for "not applicable".

Column 6 – Is the Preventive Control Applied at this Step: The Hazard Analysis worksheet allows you to break your production process into multiple steps (such as receiving or processing), and you may apply your preventive control at a step in the process other than the step where you list the hazard. Specify whether the preventive control will be applied at the specific processing step (i.e., "Yes" or "No"). **See Chapter 2, section 2.7.**