Framework for Establishing Hygienic Separation in Continuous Dairy Powder Systems in the Event of a Pathogen Positive in Finished Product

Acknowledgements

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Content Topics

1. Purpose and Background

1.1. Purpose of this Guidance Document

Continuous commercial dairy drying systems can produce a large quantity of product within a short timeframe. Combined with long production runs between extensive cleaning periods and/or complete wet washes, this can lead to large amounts of product potentially being subject to a product recall. To avoid such a massive loss of a critical food supply and crippling financial impacts on a company or the industry, preventive measures must be diligently employed. Regardless of the preventative measures employed, experience tells us that failures can still occur. When failures occur, understanding and assessing the likely or unlikely product risks of such events is worth the investment in time and resources. This guidance document intends to provide a framework for:

1) Analyzing an event in which a dairy powder produced from a continuous operation test positive for a pathogen.
2) Determining reasonable and defendable hygienic separation points before and after the positive product finding; and
3)Utilizing information and data to best identify the amount of non-contaminated powders that would otherwise be deemed necessary to discard while ensuring food safety risks are minimized.

Each scenario involving a positive pathogen finding in a continuous dairy powder operation is unique and needs to undergo a full investigation on its own merits. However, a standardized approach can help facilitate a timely and proper response. In some circumstances, engagement with a food safety professional external to the organization may prove useful in working through the investigation, analyzing the data, and developing recommendations. Engaging legal counsel to ensure compliance with statutory and regulatory requirements also is recommended.

1.2. Background

Drying is a traditional, cost-effective and reliable method used to preserve food. To this day, low-moisture foods, including dairy powders, constitute a substantial part of the human diet. Because of their low water activity, which does not allow for the growth of microorganisms, these foods have a long shelf life, from months to years. Even though growth cannot occur, many microorganisms and pathogens, such as *Salmonella*, demonstrate the uncanny ability to survive in low water activity food matrices. Desiccation and heat tolerant strains/serovars can remain dormant in dairy powders for extended periods of time. Dairy powders are typically produced as an ingredient for subsequent use in many applications: chocolates, confections, powdered beverages including infant formulas, and seasoning blends that are considered Ready to Eat (RTE). These RTE consumer products may not include a microbiological kill step during their subsequent manufacturing steps. As such, it is important to implement aggressive and effective preventative controls and food safety programs to minimize the risk of cross contamination from *Salmonella* or other environmental pathogens.

The CDC estimates every year that roughly 1 out of 6 Americans gets some type of food poisoning, which equates to 48 million people each year. This results in approximately 128,000

hospitalizations and 3000 deaths. There is an estimated cost of $152 billion a year in healthcare, workplace, and other economic losses to the United States. One of the leading organisms that is responsible for a portion of these illnesses is *Salmonella.* The presence of this organism in finished dry dairy products has led to recalls and outbreaks. Table 1 below lists a few examples of past recalls, including international instances associated with dairy powders and dried cheese. Fortunately, the industry has implemented numerous controls over the years; and now the incidence of *Salmonella* in dairy powders is considered relatively rare (Hayman et al. JFP Vol. 83, No. 10, 2020[3]).

Table 1. Recent Incidents of Pathogen Contamination Events in Dry Dairy Based Products

Year	Product	Hazard	Location
2009	Powdered Milk/Dried Whey	Salmonella	Minnesota
2016	Dried Grated Cheese	Salmonella	New York
2016	Powdered Milk/Powdered Buttermilk	Salmonella	Multi State
2018	Dried Whey	Salmonella	Multi state
2018	Infant Formula	Salmonella	France
2019	Infant Formula	Cronobacter	Canada
2022	Infant Formula	Cronobacter	Multi State

Although dairy powders undergo pasteurization, a kill step and preventative control, which inactivates vegetative pathogens in the milk prior to drying, post-pasteurization controls are critical to prevent cross contamination from *Salmonella* in the environment. One of the most significant downstream control measures is limiting the presence of water that can lead to the growth and spread of *Salmonella* if already present in the environment. In dairy powder processing environments and dryer systems (parts of which are designed for dry cleaning only), the use of wet cleaning should be restricted and only used when considered essential. Restricting water usage results in extended continuous runs between wet washing of weeks, or even months, apart.

In addition, prevention of cross contamination events is achieved through adequate facility and product contact air filtration, dryer operational controls, maintaining the hygienic integrity of the system, sanitary equipment design, robust and routine cleaning protocols, strict hygienic zoning controls, restricting to highest risk areas. The use of environmental monitoring for pathogens and indicator organisms along with product testing provides verification of effectiveness of these cross-contamination prevention programs.

1.3. Definitions

Breach - Any exposure/intrusion, planned or unplanned, of the dairy powder system or controlled hygiene area where precautionary measures are required to minimize the risk of cross contamination. An example would be pulling dryer magnets for inspection or opening the sifter.

Clean Break – The action of performing cleaning and sanitizing on food manufacturing equipment. This term may be associated with removing microbiological contamination (i.e., pathogens) associated with a positive finished product test and restoring the condition of the equipment to sanitary conditions that are suitable for continuing production with respect to finished product safety. These may be planned to mitigate the magnitude of product impact in the event of a pathogen detection or unplanned as a response to a pathogen detection.

Episodic Event – A pathogen event where the root cause investigation and/or resampling data indicates that an event occurred that allowed cross contamination but that it likely passed through the powder system without harborage.

Harborage site (niche) – A site in the environment or on equipment (e.g., junctions, cracks, holes, and dead-end areas) that enables the accumulation of residues (food debris, dust, and water) and permits the growth of microorganisms such as *L. monocytogenes* and *Salmonella*. These sites may be difficult to inspect or access and therefore can protect environmental pathogens during routine cleaning and sanitizing.

Hygienic Separation (also **Hygienic Break) -** In a continuous dairy powder system, the use of data, process records, root cause analysis findings, and/or investigative product testing to establish evidence-based food safety brackets for product disposition where appropriate. Hygienic separation may or may not be at a specific "clean break."

Indicator microorganisms - Groups of microorganisms that can be used to assess hygienic conditions and, where appropriate, indicate growth conditions that could be favorable to pathogens with similar growth characteristics.

Lot – An amount of material produced under similar conditions and conforming to a consistent set of specifications. The amount of material produced in a continuous dairy powder system designated as a lot has different meanings among companies and at times, different facilities within a company. It can be limited by either volume, time, and/or testing. An example of product lot separation may be a packaging day provided that all material is from the same source (i.e., loads of dairy), including packaging material. More information on lot definition best practices can be found in the Innovation Center for U.S. Dairy's Guidance for Dairy Product Enhanced Traceability[1].

Pathogen Environmental Monitoring Program (PEMP) - A testing protocol for sampling the manufacturing environment for pathogenic microorganisms. It is designed to verify effectiveness of sanitation and environmental control programs such as hygienic zoning.

Presumptive positive- A preliminary test result indicating there is a potential for a positive result once additional confirmatory work is completed.

Rework - Any product collected from the system or finished product that is added back, in accordance with a company's rework policies, to the system for reprocessing.

Resampling – Analyzing any additional units collected as part of the original sampling procedure or a new sample collected from the same lot tested originally. Any sample tested as part of an investigation that is not the original sample retain is considered a resample. Resampling material and then testing it is not considered retesting. Resampling changes the characteristics of the initial sampling plan, for example, by increasing the probability of rejecting lots of poor quality.

Retesting – Testing the original retain sample additional time(s) to confirm or provide additional information on an original result.

Resident microorganism - Bacterial pathogens that become established in a harborage site, multiply, and persist for extended periods of time, even years. This is the opposite of a transient microorganism. Common cleaning and sanitation practices are adequate to control the presence of transient contaminants, but such practices do not control the presence of resident contaminants once they have become established. Sanitation controls, including proper personnel practices and equipment and facility design, are key to preventing transient bacterial pathogens from becoming resident strains. Once an environmental pathogen has become established as a "resident strain," there is a persistent contamination risk for foods processed in that facility. The facility will need to use intensified sanitation procedures to eliminate the contamination.

Sanitation Verification – Protocols designed to verify effectiveness of sanitation efforts using visual inspection, ATP and/or microbiological testing.

System Purge - A complete or partial system purge is the purposeful starting and stopping of the dryer system to remove moisture and product build up by cycling through temperatures, pressures and air velocities. It can be used as part of a hygienic separation. A system purge may be required due to:

- Corrective action resulting from a positive pathogen test result
- Cleaning- which may be a complete system cleaning or separate sections cleaned such as main chamber, fluid bed, cyclones, baghouse, or components of the conveying and storage systems.
- Product changeover for allergen separation as part of allergen cleaning procedures
- Repair or modification of the dryer system, indicated by an investigation or corrective actions or equipment modification plans.

Transient microorganism – Bacterial pathogens that have only recently been introduced into the facility. This is the opposite of a resident microorganism. These organisms are typically introduced into the processing facility through, for example, incoming raw materials, 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. Generally, though, the proper application of cleaning and sanitizing in accordance with CGMPs is adequate to control the transient bacteria in the processing facility.

2. Foundational Programs

2.1. The Pathogen Equation and Beyond

Foundational food safety programs focused on preventing environmental cross contamination must be in place, and shown to be effective, for a hygienic separation other than a traditional

clean break to be considered in a continuous dairy powder system. A deeper dive into these foundational programs is included in the Innovation Center for U.S. Dairy's "Controlling Pathogens in Dairy Processing Environments: Guidance for the U.S. Dairy Industry[2]"(www.usdairy.com/foodsafety). This reference document includes the pathogen equation (illustrated below) highlighting the key foundational programs required to keep pathogens under control and avoid environmental cross contamination. These, along with other supportive programs (i.e., traceability, powder sequencing and flow through, preventative maintenance, etc.), and verification activities, must be considered when conducting a root cause analysis.

Separate Raw from Ready-to-Eat/Hygienic Zoning

History has shown that there is a greater likelihood of finding pathogens or other undesirable organisms in non-critical or raw manufacturing areas than in controlled production or Ready-to-Eat (RTE) areas. Managing the flow of personnel, supplies, air movement (dust and aerosols) and equipment significantly reduces the potential for cross-contamination.

Hygienic zoning is the process of assessing risks then defining and creating barriers to manage these risks and ultimately protect the product stream. The zoning concept can be employed to clearly separate raw wet from dry RTE areas (critical in dry product operations) and between areas of varying hygienic levels (see Table 2. below).

Table 2. Hygiene Level/Zone

Hygiene Level	Typical Processes
Critical; High Hygiene; Extra Care	Filler & packaging equipment, bin storage and conveying, direct product contact or open product, no subsequent kill step
High/Ready-to-Eat	Pasteurized product, concentrates for spray-drying with no subsequent kill step
Medium/ Basic GMP	Further heat treatment required, preliminary processing of product
General/Low	No Exposed product - Warehousing and receiving, raw ingredient storage, maintenance, corridors, pasteurizer rooms, and control rooms
Raw	Raw milk silos, raw milk receiving

(Zone names may differ by company, but processes that fall into each are typically similar. The FDA Food Safety Preventive Controls Alliance, Preventive Controls Qualified Individual training also provides an alternate hygienic zoning scheme.)

Good Manufacturing Practices and Controlled Conditions

Following current Good Manufacturing Practices (GMPs) (CFR 21 Part 117) is required by law and is one of the most fundamental expectations in the food industry to prevent contamination of products. GMPs are very broad in scope and apply to personnel, product, facilities, and production practices. Two critical GMPs for continuous dairy powder operations are controlling the presence of moisture that can fuel microbial growth and ensuring hygienic integrity of the system post-pasteurization. Identifying and eliminating water leaks, limiting water usage, minimizing breaches of the closed system, addressing powder leaks and cracks/openings/holes, and incorporating hygienic controls to ensure the hygienic integrity of the system must be employed along with monitoring and documentation of any deficiencies.

Sanitary Facility and Equipment Design

Sanitary design involves the design, construction, and installation of equipment and facilities in a manner to support effective and efficient cleaning/sanitizing and to facilitate a thorough product purging. Surfaces which are difficult to clean can be challenging and/or overlooked during a sanitation cycle, resulting in microbial harborage and growth. It is important to fully assess cleanability and identify continuous improvements to facility and equipment design. Design deficiencies that may lead to microbial risks should be documented and corrected where possible.

Effective Cleaning and Sanitation Procedures and Controls

Cleaning and sanitizing need to always be timely and effective to maintain pathogen control in the plant environment and the processing equipment. A standard protocol for cleaning with 7 steps has proven to be both efficient and effective in maintaining sanitary conditions. After sanitation it is important to visually verify CIP lines are properly drained and all internal spray devices are closed. In addition, it is imperative to verify and validate the dryer system is clean and completely dry prior to startup.

Pathogen Environmental Monitoring Program

A robust and effective Pathogen Environmental Monitoring Program (PEMP) measures the success of a dairy plant's sanitation and environmental pathogen control programs by assessing the conditions during and after production using seek and destroy tactics along with aggressive sampling and testing. PEMP results along with root cause analysis are used to drive corrective actions and continuous improvement through additional preventive actions where identified. The ultimate goal is to minimize the risk of cross contamination and prevent pathogens from taking up residence in the production environment.

2.2. Food Safety Culture

It goes without saying that to have successful and reliable foundational programs, a culture of food safety pervasive throughout the organization is optimal. Leadership is looked to for providing resources, and reinforcing communications, accountability, and behavioral examples to support these programs. The concept of food safety is paramount and should be every employee's responsibility.

3. Verification Activities

3.1. Microbiological Testing Programs

The previously discussed proactive, foundational programs must include verification through microbiological testing of finished product, process and side-stream samples, and the processing environment. It is important for the plant to establish and track its baseline microbiological profile so personnel can determine when any unusual conditions or trends occur. "In specification" or "baseline" test results should demonstrate that the drying system has the capability of producing safe and hygienic product under normal operating conditions. The side-stream product (i.e., sifter tailings), should also meet the minimal limits for food safety even if it is classified as animal feed. Conducting a facility risk assessment as outlined in "Controlling Pathogens in Dairy Processing Environments: Guidance for the U.S Dairy Industry"[2] will help identify the points where pathogens may be found in the plant and provide guidance for developing a robust sampling plan.

Product Pathogen Testing (In Process and Finished Product)

Microbiological test results of finished dry powder and in process product stream samples should be evaluated through trending and timeline graphing to demonstrate process control. This data will provide critical evidence of process control and support root cause analysis in the event of a pathogen positive.

Use of Indicator Testing

Common indicator tests utilized with dairy powder products include Standard Plate Count (SPC), Enterobacteriaceae (EB), coliforms, yeast and mold. Indicator data is typically more useful for trending because detection is more common than that of pathogens allowing a baseline to be established and allowing unexpected trends to be identified. This is especially true for SPC because it encompasses a broader spectrum of microorganisms. An increasing trend in the level of organisms detected and/or the frequency of detection can be useful to investigate an assignable root cause. Indicator results can provide insight into specific sanitation conditions in the plant, employee compliance to GMP practices and the potential for post heat-treatment contamination. Most importantly, an increase in indicator organisms can indicate that the process has gone out of control (e.g., water introduction) and can allow for proactive actions to be taken to reduce the likelihood of pathogen presence. Acceptable action limits can be found in literature or determined through trending of historical data.

Additionally, testing beyond customer specifications can prove useful in providing more consistent information for trending. For example, jumping between customer requests for coliform testing versus EB counts/detection can make the data disjointed. However, constantly testing for EB at the correct detection limit can provide continuity.

Statistical Sampling Plans

The use of a statistically valid and robust finished product sampling scheme gives reassurance that the results reflect the system's level of control. Each plant should use a statistical sampling plan that requires an appropriate number of samples across the production run to adequately demonstrate process control and properly represent the entire lot. There may be instances where an increased sampling protocol may be required, such as at start-up after a major cleaning event and/or after a pathogen detection.

When using an autosampler, the autosampler reliability tool (as found in the Pathogen Control Guidance Document for the US Dairy Industry, Appendix D) can help to validate the autosampler settings for number and size of samples. When utilizing manual sampling, the manual sampling plan should be routinely verified to ensure compliance to the statistically valid sampling plan and executed by trained individuals. Adjustment options for the auto-sampler should have limited access to prevent inadvertent adjustments that would invalidate the unit.

PEMP Tracking and Trending

A robust PEMP must include tracking and trending of results using maps and data reviews to drive additional corrective actions and guide program improvements. For example, sporadic positives in a given area may require special investigational sampling and root cause analysis to regain control. In addition, sampling patterns or frequencies may be adjusted to target problematic areas.

Pathogen Isolate Characterization

Often it is enough to know that you have a pathogen in the environment to drive corrective actions. In these cases, traditional testing to genus/species level is common and may be acceptable. However, multiple positives in the environment may require more in-depth identification to characterize and differentiate isolates. This is also true for product positive isolates, which is explained in 4.4.

Whole Genome Sequencing (WGS) is the latest technology in microbial identification and provides a DNA fingerprint of the organism and further clarity on whether an isolate is a resident or transient strain. WGS is widely used by CDC, FDA and USDA when positives are identified as pathogens. Regulators may review a plant's results to determine if positives over time are the same strain or closely related to each other. Finding the same strain over time may indicate the plant's sanitation and GMP practices are inadequate. Although helpful, it is not always necessary to go to the level of WGS to identify similar traits in repeat positives. Many companies use full O and H antigen serology or other genetic approaches, such as a RiboPrint™ analysis, which provide a level of information in between traditional speciation methods and WGS.

3.2. Additional Verification Activities

In addition to the above, additional industry verification activities that might prove useful include internal GMP audits and inspections; procedural reviews (i.e. bag-house filter changes); SSOP reviews and observations; Pre-Op checklists; War on Water audits; Sanitary Design audits; etc.

3.3. Records

The adage "*If it isn't written down it didn't happen*" certainly is applicable when it comes to assessing and justifying hygienic separation. Written programs/procedures without complete and accurate records will make root cause analysis more difficult. Section 5 provides a list of common records that should be reviewed when considering hygienic separation. Personnel creating the records should have basic record keeping skills and record storage and retention must be well defined to have a robust record history.

4. Managing a Product Positive Event

Appendix 1 provides a flow diagram depicting the typical sequence of events when a product positive notification is received.

4.1. Response Team

As with many plant initiatives and challenges, it is wise to have a cross functional team assigned to help assess, investigate, and address a pathogen event. This Food Safety/Quality Assurance led team may be comprised of representatives from plant leadership, operations, sanitation, maintenance, engineering, line operators, and legal. Upon receipt of a finished product presumptive positive result, this team should be notified and at the ready to assist.

4.2. Product Hold and Scope

Once a presumptive positive notification is received, it is important to ensure that potentially impacted product is on hold, isolated to prevent shipment, and to include a regular physical warehouse verification. If a presumptive positive test result is reported, it should be assumed to positive pending confirmation and immediate corrective actions should be taken, including planning for investigative resampling and initiating a root cause investigation. The investigation should always start upon receiving a presumptive result and should not wait until the final confirmation result is received. This immediate action reduces implicating more product or the amount of hold times until testing is completed. During the confirmation process, ensure that the following product is on hold:

- All product associated with the impacted lot, preceding lots based on company policy (typically 2 previous lots) or back to the last clean break on all shared equipment, and all lots following until the investigation is complete
- All the side-stream products such as tailings, nuisance dust, scrape-down or plug-up lumps and any lots associated with any of these side-streams as well as any product associated with animal feed; and any products associated with dry blend rework (including original source of rework).

When determining scope of product potentially impacted, special consideration must be made for product sequencing and flow through. In many operations the first liquid into a drying process does not necessarily equate to the first powder packaged at the end of the process. This can be due to different process configurations, including different combinations of dryers, silos, packaging lines, etc. For example, there may be times where dried product is stored within the system (e.g., in a silo prior to packaging) while other product dried later is packaged first. It is important to understand and document this flow within the process because any justification for a hygienic break will be based on tracking of product within the system, as well as microbiological results in relation to the timing of the positive pathogen finding.

The Hold and Release program should consider all product that may be implicated. All lots and associated side-streams should be placed on physical and electronic hold. Industry best practice is to keep product lots and associated side-streams on hold for the length of time it takes to get results for all pathogens tested on impacted lots. Considerations that may increase amount of held product:

- When samples are collected by a regulatory body for pathogen or compliance testing.
- Customer sampling and testing for compliance upon receipt at their factory or regulatory sampling at the customer's factory.

Note: Any product out of the manufacturer's control that may present a risk of serious adverse health consequences or death to humans and animals should be reported to the FDA Reportable Food Registry within 24 hours of this determination.

4.3. Immediate Corrective Action

Establish New Clean Break

Following the detection of a pathogen in finished product, the drying system should be thoroughly cleaned and sanitized. This will give the system a fresh "clean break" pending the root cause investigation. Cleaning and sanitizing to establish a clean break should include conducting all CIP washes on equipment, that are possible, and conducting tear down & manual cleaning of equipment of non-CIP equipment. Prior to any CIP or manual wet cleaning, the drying environment must be thoroughly dry cleaned to help protect against cross contamination as the closed system is opened up. Also, great care must be taken to minimize or eliminate the introduction of water into the dry clean only environment during CIPs or manual cleaning. If possible, manual wet cleaning should be conducted "off-line" and outside of the dry clean only area. Any moisture that is introduced into the drying environment must be completely removed/cleaned/sanitized and dried out. All equipment that is CIPed or manually wet cleaned and sanitized must be verified as dry prior to resuming production.

After cleaning and sanitizing, a system purge, along with intensified testing, is often used to help further create and verify "clean break" separation – especially in equipment that is not readily CIPed or disassembled for manual cleaning. A purge cycle consists of the start-up of the system, drying of a minimal amount of product, and system shutdown. Multiple start up and shut down cycles may be conducted to complete the purge process depending on the situation, as well as the size, complexity, and hours of operation of the dryer and packaging system. Start up and shut down cycles should take into consideration the inlet and burner fans, dryer conveying systems, and powder conveying systems to storage and to packaging spaces.

Intensified Product Sampling/Testing

After product positive test results, an intensified sampling plan for microbiological testing of the finished product, side streams, and/or the production environment is prudent. This may include collecting more samples than normally collected and/or in the case of product samples, testing a larger amount per lot than the normal program (e.g. testing 1500 g per lot or sublot versus 375 g). The intensified sampling plan should be used until confidence in the ongoing hygienic conditions of the process and/or environment is reestablished, at which time the intensified level of sampling can return to normal.

Example of purge process and increased testing:

- 3-5 purges of the dryer, full start-up and shut-down
- Run each purge long enough to collect enough sample based on increased testing requirements
- Collect 5 pounds of sample from each purge and test for pathogen
    - *Salmonella* 5x375 grams
    - For each of the 3-5 purges, means there will be 15-25 375 gram aliquots

4.4. Confirm Results and Conduct Isolate Characterization

Confirmation

When the laboratory reports a presumptive positive, it should also communicate how and when confirmation work will be conducted. If the confirmation process is not completed for a presumptive result, then the result must be considered positive, and all subsequent corrective actions taken accordingly.

If presumptive results are confirmed negative, it may not be necessary to carry forward the complete investigation. However, persistence of presumptive results that confirm negative should be investigated to determine if closely related organisms may be present within the process/product or if the food matrix is interfering with the test method performance. Additionally, a presumptive which results in a negative confirmation could indicate sanitation deficiencies exist requiring investigation especially when the event repeats itself.

Isolate Characterization

Similar to environmental isolates as noted in section 3.1, it may be useful to characterize product isolates using differential technologies. This information can then be compared to previous product and environmental isolates to aid in the root cause determination. Resident and transient strains are equally problematic as they both could present a food safety risk to consumers if cross contamination were to occur. However, as noted in their definition, resident strains have a greater tendency to result in cross contamination simply because they have become more entrenched in the environment and are more difficult to control.

4.5 Accuracy of Results

Laboratory Errors

Although rare, laboratory errors can and have occurred. Any product investigation should at least consider and work to minimize this possibility in parallel with the plant investigation. Possible laboratory errors are contamination of a product sample with either a laboratory positive control or material from another product sample that was positive. The laboratory should have their own internal QA investigation and should also report the results of that investigation to the appropriate responsible parties.

Note: Retesting and/or resampling product associated with initial confirmed positive and obtaining all negatives does not, by itself, mean the initial result was due to a lab error. It is not possible to test out of a positive result.

A laboratory error can only be determined/confirmed by the laboratory that conducted the initial assay. Unless the initial testing laboratory provides a written declaration that the initial positive result was in error, the initial result must be considered correct.

Sampling Errors

Sampling and/or resampling at the plant could also be a cause of a false positive result due to cross contamination if aseptic procedures are not properly executed and should be investigated.

Carefully review, inspect, and observe sampling systems (i.e., autosamplers) and procedures. Environmental sampling may be used to verify any possible routes of cross contamination.

4.6. Initiate Investigational Resampling

For scope and root cause analysis, it is important to understand the frequency, time frame, and location of any additional positives with the finished product. This can be achieved by conducting intensified resampling and testing of finished product from the implicated production run.

Note: Retesting and/or resampling product associated with initial confirmed positive and obtaining all negatives does not and cannot negate the original positive result. This resampling/testing is for investigational purposes only. Again, it is not possible to test out of a positive result.

Resampling of Affected and Adjacent Lots

Resampling is different than retesting. Resampling is conducted in the context of this document to find the beginning and/or end of a problem and support root cause analysis.

- When did the contamination event begin (or at least when is the earliest time that it can be detected through sampling and testing?)
- How long did the contamination event last?
- How much product may be implicated?
- Does this appear to be an episodic event?

This investigative resampling would usually include the preceding and following lots relative to the implicated lot. Additional lots may need to be included if there are clear connections to these lots by production records, process flow and/or test results. The scope of re-sampling should consider any lot-to-lot connections via side-streams or activities that include sifter tailings, bag house returns, scrape-down, nuisance dust from packaging line, rework, silo co-mingling, and/or animal feed streams.

Resampling Approaches and/or Additional Sampling

Statistical resampling protocols should have a similar or more sensitive and intensive sampling plan than the original sampling plan to detect pathogens. For example, an n=60, or greater, of each lot versus routine testing may be followed to achieve this.

"Grab Samples" from pallets

Retained samples from your routine product sampling program may not be adequate to fully characterize an event, especially for timeline sequencing. If manual sampling (grab samples from finished inventory) is required after product is packaged, an n=60 or greater statistically valid plan is recommended. Follow a documented plan to ensure uniform sampling across the lot. An example of manual sampling for product packaged in 25kg bags; 100g sub-samples are pulled from throughout the lot in question. The goal is to collect at least 4 composite samples of 375g (each 375g sample contains 15 samples of 25g) each to meet the n=60 (1500g total) of the statistical plan. The FDA BAM method recommends utilizing this sampling approach when testing Category 1 products for *Salmonella* and is commonly followed in the dairy industry when higher testing sensitivity is necessary. If executed properly, the resampling plan may help determine an assignable root cause.

5. Root Cause Analysis

5.1. Approach

When a finished product sample is reported as presumptive and/or confirmed positive for a pathogen, an investigation must be conducted in an attempt to determine the root cause for the product contamination. A good approach is to use multiple tools including records/document reviews, microbiological data, line inspections, observations of practices and operations in real-time and through available camera footage, plus interviewing key employees to build an entire picture of the circumstances surrounding the event. Each production facility, process design, and contamination event is unique and should be carefully considered when conducting a thorough root cause investigation. There is not a "one size fits all" approach for root cause identification. The following provides some examples of common investigational approaches to use when investigating a contamination event. This section provides guidance on information gathering to support the root cause investigation.

- The key root cause questions to be answered include:
  - What can I learn or need to learn about the scope of contamination?
  - How may the contamination have occurred?
  - What may have happened during production or sampling, that could have resulted in the positive result?
  - Does this appear to be an "episodic" or an "internal harborage" event?
  - Can a hygienic break be identified to properly bracket product for disposition?

Typical process and QA records to review and possible evidence to gather when investigating if there were deviations from normal operations or processing conditions include, but are not limited to:

- Process control records
- Pasteurization records
- Evaporator records
- Dryer records
- Maintenance records for preventive maintenance performed
- Work orders or red tags
- Filter changes
- HVAC maintenance
- Routine or special case intrusions into the system
- Clearing powder plugs/build up
- Magnet checks
- Leak detection/repair
- Monitoring of sifter overs, humidity, and air pressurization records
- Weather
- Structural failure
- Contractor activity
- Unexpected down times
- Other unusual events

- Internal audit reports
- Finished product microbiological test results
- Sanitation verification results
- PEMP results and trending

5.2. Microbiological Data

Pathogen Environmental Monitoring Program (PEMP) Testing

Like product testing results, the results from the PEMP can be valuable during an investigation into a pathogen positive event in finished product. It is important that these programs are robust and well maintained to be of value during the investigation, including thorough documentation of program activity to establish a detailed timeline of events.

It will be important to understand any recent pathogen findings in the environment. When reviewing and trending data as part of an investigation, a timeframe of at least the previous 12 months (accounting for seasonal impact and rotating sampling sites/areas over time) may be appropriate.

If there has been recent activity, consideration must be given as to which zone the positive was found. If zone 2 (near product contact), there may be a higher likelihood that a product cross contamination event could have occurred compared with zone 3 or zone 4. It will also be important to understand if the true source of the pathogen was determined and then eliminated, or if the true source was not determined with confidence. Another consideration are recent environmental events (e.g., plant construction, roof leak) where the environment could have been compromised. If an event took place, samples should have been collected and the results may offer evidence of environmental concerns.

As part of an investigation, it may be valuable to initiate additional intense sampling of the environment (i.e., a swab-a-thon). A survey of the environment, along with specific attention to potential cross contamination areas, may aid in the investigation. Questions to consider:

- Over the past 12 months have any pathogen positives been experienced in the process environment where this product was produced, conveyed, or packaged?
- Were any positives in close proximity to zone 1?
- Did the vector sampling and investigation at the time provide an assignable root cause?
- Did subsequent testing verify effectiveness of corrective actions?
- Are there any plausible scenarios where cross contamination from this/these environmental sites could enter the product stream?
- Were isolates characterized to allow comparison to product isolates?
- Have any PEMP resident strains been identified and are there any matches with the positive product?

Characterizing environmental isolates to understand if you are or may be dealing with a resident strain is a proactive approach.

More aggressive control measures may be needed, including PEMP vectoring for root cause/niche sources and deep clean sanitation tactics to handle resident strains. The PEMP vectoring will often reveal a resident situation where initial corrective actions in a particular area do not result in timely remediation. On the other hand, finding a specific strain more than one time does not automatically mean you have a resident strain. A transient strain could be introduced at different times from external sources. If PEMP vectoring and corrective actions appear to remediate, but then the same strain is found in another location at a later time with similar successful remediation, part of the root cause should focus on introduction from external sources, such as foot/wheeled traffic from non-manufacturing areas, water ingress into the building, building air systems, and pest control.

Indicator data review as part of the investigation

A review of indicator organism results can also be useful during an investigation. It will be important to understand the trending of the data versus baseline and/or acceptance limits. Questions to consider:

- Are there any unusual trends in the indicator data that may point to a developing internal system harborage or possible sanitation/GMP failures?
- Are there any spikes in indicator data that match the product positive timeline and may indicate presence of uncontrolled water fueling microbial growth in the process or the process environment?

5.3. Maintenance Activity

Certain types of maintenance activities may contribute to cross contamination risks and must be included as part of the root cause investigation. Questions to consider:

- Was there scheduled or unscheduled maintenance activity on the line or in the production area during or before the contamination event. Are there adequate records for these events?
- If maintenance activity occurred, do you have a procedure outlining how to protect the product zone during these events? Are there records that show these procedures were followed?
- Have interviews of maintenance, engineering, contractors, and operations occurred to verify the information found in the records?
- Does a documented maintenance program for dedicated/captive tools and their sanitation exist? Are there records confirming procedures were followed?
- Are maintenance tools dedicated and swabbed as a part of the control program?

5.4. Downtime

Non-operating times often present a risk due to temperature variation, potential condensation formation, and system breaches that may occur. Questions to consider:

- Was there scheduled or unscheduled downtime during or before the contamination event?

- Was there an unusual amount of downtime and what was the reason for the downtime?
- Are there robust records of activities associated with the downtime?
- Did excessive downtime anywhere in the system interfere with normal rework, traceability, or other powder handling practices?
- Did the downtime create conditions within the system that increased risk?
- Was the system breached?

5.5 Sanitation Activities

Sanitation is conducted to remove soils and undesirable microorganisms from equipment and environmental surfaces. However, sanitation can become a source of contamination if not properly executed. Questions to consider:

- Were there any abnormal findings in the sanitation documentation?
- Was anyone new or unfamiliar with sanitation practices involved, such as a trainee or someone filling in during a normal operator's vacation or absence?
- Were the employees trained against the Sanitation SOPs and is training documented?
- Have we cleaned a known positive area with commonly shared cleaning utensils like vacuums, brushes, or wipes?
- Was this a wet or dry sanitation?
- Any unusual circumstances occur during cleaning?
- Was the system verified as completely dry, if wet sanitation took place, before starting back up?
- Was compressed air used in the environment or introduced into the dryer system?

5.6.Construction Events

Walls, floors, ceilings, and support structures are known harborage sites for pathogens which could be released by construction work. In addition, maintenance and contractor equipment or activities could introduce and spread external pathogens if containment measures are inadequate. Questions to consider:

- Was there construction activity on the line or in/near the production area during or before the contamination event?
- What were the controls set-up to protect the product zone if construction was in the area?
- What data is available to verify the construction zone was being controlled?
- Were any deviations recorded?
- What controls for dust from construction zones and air handling were put in place?
- What legacy construction has happened in the impacted area of the plant?
- Were extra environmental swabs taken within the construction areas? Any positives?

5.7.Other Production Records and Abnormalities

Production records provide an insight into any deviations or loss of control during production campaigns. Good records will show if any potential issues or problems occurred and when.

Below are examples of production areas and records, along with potential findings that may indicate varying levels of loss of control, that should be reviewed. Some of these activities represent routine and non-routine opening of the system that could be a source of cross contamination.

- Sifters/screens – Increased or less than normal amounts of tailings, clumps or clumping that may indicate the unintended introduction of moisture or water somewhere in the system.
- Powder mills
- Magnets
  - Excessive metal on magnet
  - Cracks in magnet
  - Leaks around magnet door gasket
- Rotary air lock issues and/or seal vent line plugged/compromised
- Tube selector or other valve issues related to powder conveyance
- Bag houses – Inspection or replacement of dropped or ripped bag filter
- Fluid bed/static bed – Blinded or high level, possibly requiring scraping
- System pressure variations beyond normal
- Utility interruptions or surges
- Identification of worn or cracked direct product contact equipment (boots, rotary valves, stainless steel components, sifters, etc.)

5.8.Plant Trials and Projects

Review records for any trials or projects that may have changed normal operation. Examples of these activities include:

- Were any additional sampling locations included in the sampling plans?
- Were any manual processes used during the operations?
- Was any new equipment being used?
- Were there any new personnel in the production area?
- Were there new ingredients introduced to the system?

5.9.Introduction of water to the dry environment

Review records for any potential introduction of water and/or moisture to the dry environment that could fuel excessive microbial growth increasing the risk of spread. Examples may include:

- Were any overhead water leaks identified, especially if caused by roof or utility issues?
- Was any water in compressed air lines identified with no submicron filters at point of use?
- Was pneumatic air conveying dehumidifier inspected to ensure it was not full of water, leaking or having very dirty or cracked coils?
- Were there any leaking water flush check-valves on hard piped water flush lines?
- Were CIP pop outs inspected?
- Were there any failed high pressure pump packings or centrifugal pump water seal?
- Was there any water trapped between ferrule and plastic boot material on drop leg boots on cyclones or transition ducts?

- Were sonic horns or fluidizers in product lines supplied with compressed air inspected?
- Were there any issues with utilities outside the hygiene zone in which moisture may leak into room through entryways?
- Was the fire suppression system in the room and dryer inspected for leaks?
- Was there any other evidence of water use, standing water, condensations, or drain back-ups?

5.10.Operator Interviews

Were areas verified dry prior to starting back up after a controlled wet clean or unplanned personnel activity that introduces water? Engage operators in the effort to characterize any unusual activities that may have taken place on or near the line. Interviewing them can uncover additional information or add clarity to records. The person being interviewed should understand the purpose and importance of the questioning to encourage an open dialogue and should be encouraged to be forthcoming, even if mistakes are identified.

Key questions:

- What might an operator have seen, heard, or performed that was not previously documented or part of normal plant operations?
- What might an operator be able to add to the operational records with their observations?
- Are there notes in operation/equipment logs that need clarification?
- Ask the operators to walk you through the process of setting up for production and/or CIP? Compare against the SSOP/SOP and note anything unusual or that has been normalized but may be a contributing factor.

5.11.System Breaches

Any disruption to the normal operations of the manufacturing process could be a breach and should be considered for breach control protocols. Routine breaches are necessary planned activities that are performed at a set frequency to maintain process control in sensitive areas and should have documented procedures and verification to reduce the risk of contaminating the system. Examples of routine breaches:

- Magnet checks, sifter-checks, mill checks
- Rotary airlock maintenance
- Blower dehumidifier cabinet cleaning
- Supply or conveying air filter changes
- Building HVAC filter changes for high care areas
- Checking integrity of dryer system filters
- Guillotine/blank entry/exit
- U-tube, Baghouse, or Fluid bed inspections

Whether a breach was planned or unplanned, it can increase the risk to the product zone.

Documented procedures should be in place to make sure trained personnel handle the system breach appropriately and avoid contaminating the system. Enhanced environmental swabbing after start-up can be performed to verify sanitation effectiveness.

Questions to consider:

- Was there a planned or unplanned breach during this time period? Capture details.
- Were any issues encountered that may have put product at additional risk?
- Was the High Hygiene area (i.e., filling room) breached or have greater personnel activity than normal?
- Were protocols followed and documented?

Appendix 2 captures the above considerations and questions in a format titled "Root Cause Investigation Coversheet" that can help organize your root cause investigation.

6. Assessing Your Situation Based on Investigation Findings

6.1. Response Team Review

The response team should meet to review all root cause investigational findings to draw a reasonable conclusion as to the cause of the cross contamination and determine, based on the pattern of resampling results, if this was an episodic event and if a hygienic separation could be established before and after the positive event.

To assist in the discussion, assemble the data in an easy-to-follow format. The team lead should start by presenting the compiled evidence to the response team. Each member of the team should keep a healthy skepticism about the facts of the event. This is the time to ask challenging questions. Are all the important elements of the event supported with data or facts? If not, is there any additional data or facts that can be gathered to solidify parts of the story?

6.2. Assignable Root Cause

Based on the investigational work conducted, can an assignable root cause be reasonably linked to the timing of the event as supported by the resampling results and data/facts collected? In reality, there are times where a root cause cannot be reasonably assigned. Do not try to force fit a scenario if the documented data and records do not support it. This will need to be taken into consideration when determining hygienic separation as discussed in the following section. Obviously, an assignable root cause is advantageous in support of decision making and corrective action and preventive action (CAPA) next steps. However, if the investigative resampling strongly supports a limited episodic event, the lack of an assignable root cause becomes less of a hurdle.

6.3.Resampling

As noted in section 4.6, additional intensified resampling (this sampling is in additions to the investigative sampling) is useful during an investigation to establish the level and scope of contamination present. Results of the resampling can be difficult to interpret at times but can also bring clarity to the situation. No additional positives are good news in that whatever cross contamination occurred, it was at a very low level; however, it can also leave you with additional

questions. Additional positives are an obvious concern but can possibly help define the type of contamination experienced. Upon receipt of the resampling test results, it is sound practice to lay the results out on a timeline to discern any potential patterns. Patterns are typically one of two types – single or multiple clusters.

Single Cluster Positive(s):

A single positive sample or a single cluster of positive samples may indicate that once the product or product stream was contaminated, the contaminated material moved through the production system and was purged from the system. The investigation should be focused on identifying the likely contamination event and resampling product made before, during, and after the positive samples to confirm that this is an isolated or "episodic" event.

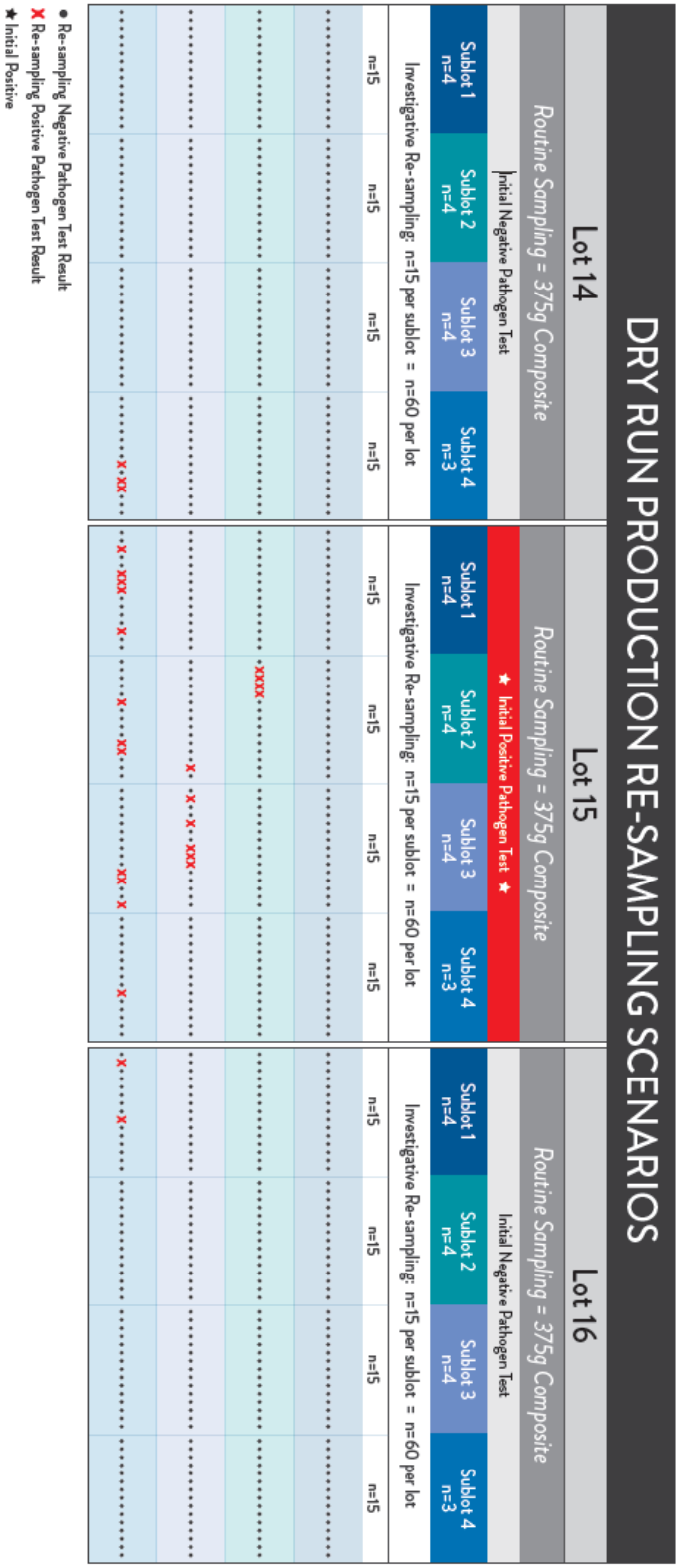
Multiple Cluster Positives

Multiple positive samples or clusters of positive samples may indicate more than one "episodic" contamination event introducing the pathogen to the product stream or that once the product was contaminated, the contaminated material has become hung up at spots within the system. Alternatively, the initial contamination level may be low and therefore only detected intermittently by the sampling plan. The investigation should be focused on identifying the likely contamination event(s), resampling product made before, during, and after the positive samples, and identifying any potential hang up points within the process such as ledges, elbows or nooks within the equipment.

Figure 1 below illustrates 4 different hypothetical scenarios on how to interpret and react to each unique data set when trying to establish hygienic separation after a positive result. In these scenarios, one of the initial composite samples of lot #15 of a production campaign tested positive for *Salmonella.* The standard testing plan includes 1-375g composite per lot made up of 15-25g samples. In response, intensive re-sampling and testing for *Salmonella* was conducted on each of lots 14, 15 and 16. In this example, each lot was tested at n=60 with all 60 individual 25g samples tested separately for *Salmonella* to help create a timeline of results. The results of the re-samples are different for each scenario, with positive results noted by a red "x."

Note: Each company develops run, lot, sublot, and testing protocols based on process design, business needs and customer requirements. The following depicts a generic example for discussion purposes only.

Figure 1. Resampling Scenarios



6.4.Discussion on Scenarios Depicted in Figure 1.

Scenario 1 - No Additional Positives

In Scenario 1, no additional positives were found after intensive resampling of the implicated lot #15 or the buffer lots 14 and 16. This would strongly indicate that this was a very focused episodic event. While no additional positives were found, it is still recommended to complete and document all appropriate remediation steps and root cause analysis. **Note:** The fact that no additional positives were found upon resampling does not negate or override the initial positive.

Companies in this situation should consider the totality of the evidence. If an assignable root cause (ARC) is identified and the timing aligns with production of the implicated Lot #15 and all additional microbiological data is typical, they may consider release of lots prior to buffer lot #14 and after buffer lot #16 but choose to reject both buffer lots #14 and 16 in addition to the positive lot #15 to be conservative.

Scenario 2 - Single Cluster Positives

In Scenario 2, the intensive resampling of lots #14, 15 and 16, indicated the contamination was an isolated event closely clustered around the original positive result. There were no additional positives in adjacent lots which reasonably indicates the contamination moved through the system and there is not a systemic contamination. Data indicates this was likely an episodic event.

Similar to Scenario 1, companies in this situation should consider the totality of the evidence. If an assignable root cause (ARC) is identified and the timing aligns with production of the implicated Lot #15 and all additional microbiological data is typical, they may consider release of lots prior to buffer lot #14 and after buffer lot #16 but choose to reject both buffer lots #14 and 16 in addition to the positive Lot #15 to be conservative. Since the resampling did detect more than one positive, release of buffer lot #14 would be more difficult and likely not considered. If no ARC is identified, intensified resampling and lot rejections may expand because of the lack of clarity of impacted product.

Scenario 3 - Multiple Cluster Positives

For Scenario 3, the resampling activities indicated the contamination had less consistent and non-discreet grouping of positives; but may still be limited in scope. To further clarify these results, a company may prudently expand testing to additional production lots, such as lots #13 & #17 per this example. Obviously, a larger portion of the production must be placed on hold pending these results.

Again, considerations for identifying hygienic separation and product disposition will depend on whether an ARC was determined, and timing was in conjunction with the test results. If an ARC is identified and evidence and subsequent resampling (no additional positive detected) indicates a larger but still episodic event, companies would reject all lots with any positive test results, and likely several buffer lots as well. However, consideration must give to this being a harborage versus an episodic issue. If no ARC or a weakly linked ARC was determined, further intensified

resampling and investigation may be needed to better define where the appropriate hygienic separation can be established.

Scenario 4-Multiple Cluster Positives

In Scenario 4, the resampling activities have not established a bracket of lots that test negative for pathogens on either side of the original positive incident. A company presented with this scenario will have to carefully consider its next remediation and mitigation activities including consideration of all product produced between the current clean break wet wash brackets. The company should start sampling additional lots on either side of the incident to investigate the scope of the contamination and attempt to establish a proper hygienic separation break or utilize the last documented sanitation clean break. This testing could have food safety and/or regulatory considerations if product is outside of company control and should be considered carefully by company leadership and appropriate legal counsel. This data indicates that there may have been an intermittent contamination event or possibly an internal harborage point. The root cause investigation and possible internal system and/or disassembled equipment sampling/testing is critical to help form appropriate corrective actions beyond clean & purge.

All product lots and any side-stream material determined to be implicated will need to be safely and appropriately dispositioned. Product from the entire campaign, and any side-steams, back to the last validated clean break may need to be recalled from the market.

6.5.Applying Hygienic Separation Concept using the Above Example Scenarios

Table 3 summarizes and expands upon the scenarios presented above and provides considerations and thought processes for hygienic separation. Questions to help drive disposition decisions include:

- What was the pattern of positives if any from the investigative resampling?
- Do you have a full grasp of product flow and know all associated product?
- Have there been any upward trends or unusual spikes in product indicator counts?
- Have there been any unusual PEMP findings indicating a potential product stream risk?
- Does the evidence suggest that the event is episodic versus an internal harborage?
- Were you able to identify a reasonable assignable root cause?

Table 3. Scenario Examples

Scenario #	Resample Pattern of Results	Assignable Root Cause Identified	Episodic Event	Hygienic Separation* Possible (* Other than clean break)
1	No Clusters	None Identified	Very Likely	Yes
2	Single Focused Cluster	Yes; unplanned breach for maintenance work	Likely	Yes with caution; consider exapnding resampling to verify
3	Multiple Clusters Limited Time Period	Yes; planned breach but SOP failures noted	Likely	Possible; expand resampling to verify; closely review records for expand lots
4	Multiple Clusters Broad Time Period	Yes; niche condensation identified	No	Unsupportable
	Examples above assume investigation found that all PEMP and microbiological data were typical.			

7. "Putting It All Together"

7.1. Data Driven Product Disposition

In summary, each event will have its own unique circumstances, and the information discussed in this document must be collected and reviewed together, as a complete scenario, in order to make the best decision for product disposition that minimizes food safety risks.

Utilize the information and tools in this guidance as appropriate to assist in managing, investigating, and documenting any events you may experience. It will always be easier to defend any decision including hygienic separation when supported by well documented data and facts. Document the decision made regarding the disposition of the product and why that conclusion made based on the facts.

7.2. CAPA

There are always learnings to be gained from every event with an opportunity for continuous improvement. The response team should determine and document all immediate, short, and long-term corrective and preventative actions.

7.3. Documentation

It is critical to capture all results, records, corrective actions, and response team notes in support of any product disposition decisions. Maintain records per company policy or legal team recommendations. These investigation and disposition documents may be reviewed years later with new people on the team having to answer the questions accurately and concisely. Consider the audience as you finalize the disposition and investigation report.

References:

1. Innovation Center for U.S. Dairy Guidance for Dairy Product Enhanced Traceability Voluntary Practices and Protocols for Strengthening the U.S. Dairy Supply Chain. 2016.
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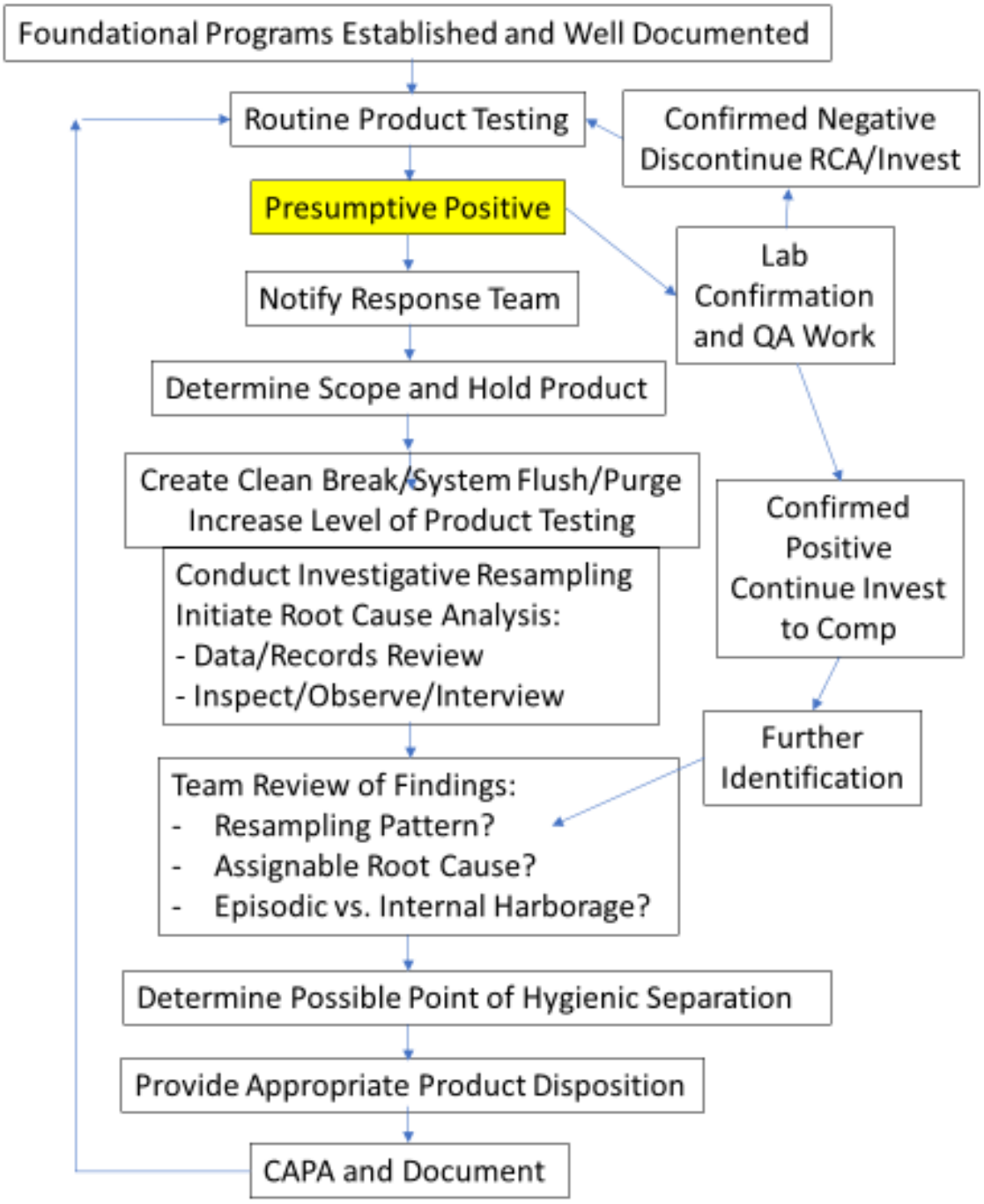
4. Cook, D. (2021, April 15). Cronobacter: Pathogen Considerations beyond Salmonella in Dairy Powders. Food Safety. April/May 2021. Online version
5. Control of Salmonella in Low-Moisture Foods. GMA. 2009 February 4.
6. Hasmukh, P. Best Practices for Excellence in Milk Powder Manufacturing: A guide for manufacturers. U.S. Dairy Export Council. 2013

Appendix 1

Positive Event Action Steps



Appendix 2

Root Cause Investigation Coversheet

Records Review:

Records to Review	Reviewed	Date Range	Any Deficiencies or Abnormalities
• Process control records			
• Pasteurization records			
• Evaporator records			
• Dryer records			
• Maintenance records for preventive maintenance performed			
• Work orders or red tags			
• Filter changes			
• HVAC maintenance			
• Routine or special case intrusions into the system			
• Clearing powder plugs/build up			
• Magnet checks			
• Leak detection/repair			
• Monitoring of sifter overs, humidity, and air pressurization records			
• Weather			
• Structural failure			
• Contractor activity			
• Unexpected down times			
• Other unusual events			
• Finished product microbiological test results			
• Sanitation records, pre-op and verification results			
• PEM/EMP results and trending			
• Other			

Investigational Questions:

Maintenance Activity

Was there scheduled or unscheduled maintenance activity on the line or in the production area during or before the contamination event. Are there adequate records for these events?

If maintenance activity occurred, do you have a procedure outlining how to protect the product zone during these events? Are there records that show these procedures were followed?

Have interviews of maintenance, engineering, contractors, and operations occurred to verify the information found in the records?

Does a documented maintenance program for dedicated/captive tools and their sanitation exist? Are there records confirming procedures were followed?

Are maintenance tools dedicated and swabbed as a part of an PEMP?

Downtime

Was there scheduled or unscheduled downtime during or before the contamination event?

Was there an unusual amount of downtime?

What was the reason for the downtime?

Are there robust records of activities associated with the downtime?

Did excessive downtime anywhere in the system interfere with normal rework, traceability, or other powder handling practices?

Did the downtime create conditions within the system that increased risk?

Was the system breached?

Was the High Hygiene area (filling room) breached or have greater personnel activity than normal?

Sanitation Activity

Were there any abnormal findings in the sanitation documentation?

Was anyone new or unfamiliar with sanitation practices involved, such as a trainee or someone filling in during a normal operator's vacation or absence?

Were the employees trained against the Sanitation SOPs and is training documented?

Have we cleaned a known positive area with commonly shared cleaning utensils like vacuums, brushes, or wipes?

Was this a wet or dry sanitation?

Any unusual circumstances occur during cleaning?

Did we conduct maintenance during the sanitation cycle?

Was the system verified it was completely dry, if wet sanitation, before starting back up?

Construction Activity

Was there construction activity on the line or in/near the production area during or before the contamination event?

What were the controls set-up to protect the product zone if construction was in the area?

Were any deviations recorded?

What data is available to verify the construction zone was being controlled?

What data and/or documentation is available for contractor and people controls?

What controls for dust from construction zones and air handling were put in place?

What legacy construction has happened in the impacted area of the plant?

Were extra environmental swabs taken within the construction areas?

Other Production Records and Abnormalities

Sifters/screens – Increased or less than normal amounts of tailings, clumps or clumping that may indicate the unintended introduction of moisture or water somewhere in the system, scorch or extraneous

Powder mills

Magnets

Excessive metal on magnet
Cracks in magnet
Leaks around magnet door gasket
Bag houses – Inspection or replacement of dropped or ripped bag filter
Fluid bed/static bed – Blinded or high level, possibly requiring scraping
System pressure variations beyond normal.
Utility interruptions or surges.
Identification of worn or cracked direct product contact equipment

Plant Trials and Projects
Were any additional sampling locations included in the sampling plans?
Were any manual processes used during the operations?
Was any new equipment being used?
Were there any new personnel in the production area?
Were there new ingredients introduced to the system?

Introduction of water to the dry environment
Overhead water leaks caused by roof or utility issues
Water in compressed air lines with no submicron filters at point of use
Pneumatic air conveying dehumidifier full of water, leaking or very dirty coils.
Leaking water flush check-valves on hard piped water flush lines
Failed high pressure pump packings or centrifugal pump water seal.
Water trapped between ferrule and plastic boot material on drop leg boots on cyclones or transition ducts
Sonic horns or fluidizers in product lines supplied with compressed air
Issues with utilities outside the hygiene zone in which moisture may leak into room through entryways.
After a controlled wet clean or unplanned personnel activity that introduces water, the area needs to be verified dry prior to starting back up
Is this appropriate here, if these are in the dry area, this may not be abnormal introduction of water?

Interviews
What might an operator have seen, heard, or performed that was not previously documented or part of normal plant operations?
What might an operator be able to add to the operational records with their observations?
Are there notes in operation/equipment logs that need clarification?

System Breaches
Magnet checks, sifter-checks, mill checks, rotary airlock maintenance
Blower dehumidifier cabinet cleaning
Supply or conveying air filter changes
Building HVAC filter changes for high care areas
Checking integrity of dryer system filters

System Inspection

CIP "pop-outs"
Bag house manifolds
Atomizer portals
Pneumatic conveyance flanges
Dehumidifiers
Air system filtration
Rotary feed valves
HPP
Internal dryer shells

Product Disposition Questions:

What was the pattern of positives if any from the investigative resampling?

Do you have a full grasp of product flow and know all associated product is on hold and accounted for?

Have there been any upward trends or unusual spikes in product indicator counts?

Have there been any unusual PEMP findings indicating a potential product stream risk?

Does the evidence suggest that the event is episodic versus an internal harborage?

Were you able to identify a reasonable assignable cause?

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