MICROBIOLOGICAL SAFETY VALIDATION OF FOOD PROCESSES

Introduction

The Food Safety Modernization Act (FSMA) was signed into law on January 4, 2011 by President Obama. It represents the largest expansion of food safety requirements and FDA food safety authorities since the enactment of the original Food Drug & Cosmetic Act in 1938. It adds Section 418 to the US FD&C Act, requiring facilities to perform a hazard analysis and implement a preventive controls plan. The intent of the law is to protect foods from exposure to known or reasonably foreseeable biological, chemical (including allergens and economically motivated adulteration), physical and/or radiological hazards. In total, FSMA requires the FDA to produce approximately 50 new regulations and guidance documents addressing federal food safety requirements.

At the core of the FSMA legal requirements (hazard analysis and preventive control plan) are two key regulations:

1. Current Good Manufacturing Practice, Hazard Analysis and Risk-Based Preventive Controls for Human Food, 21 CFR Part 117 (PC Rule HF). Final rule was released in September 2015. Large companies must be in full compliance with the rule by September 2016. Small companies and very small companies must comply by September 2017, and September 2018, respectively.
2. Current Good Manufacturing Practice, Hazard Analysis and Risk-Based Preventive Controls for Animal Food, 21 CFR Part 507 (PC Rule AF). Large companies must comply with cGMP provisions by September 2016 and with Preventive Controls provisions by September 2017. Small and very small companies have an extra year for each provision respectively.

Both of the aforementioned Preventive Control Rules require a hazard analysis intended to identify microbial hazards associated with specific food products. Furthermore, the rules require the implementation of preventive controls to prevent or minimize the identified risks. A critical component in assessing the efficacy of a microbial control measure is the execution of a scientifically sound validation process. Following validation of the microbial control measure, verification and monitoring procedures must be implemented to ensure that the control measure is operating as intended.

Validation of a control measure may be accomplished using various approaches, as explained later in this document. One such approach is to intentionally introduce the microbial target into the food product, processing equipment or package material and expose the contaminated matrix to the control measure (process) at the production facility. Following exposure to the process the recovered product is analyzed to evaluate the efficacy of the control measure in destroying the target organism. However, it is not prudent or recommended to introduce a pathogenic organism into a food processing environment. In order to circumvent this problem, Covance utilizes non-pathogenic microorganisms (surrogate organisms) that mimic the behavior of the actual pathogen against the specific control measure being evaluated. The selection and evaluation of an appropriate surrogate is essential in executing a scientifically-sound validation process. This document discusses in detail the various approaches to validation including the use of surrogates.

What is validation?

The Preventive Control Rule for Human Foods similarly defines validation as “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.” In other words, validation attempts to answer the questions: Are the process parameters the right ones? Will they work? Validation is clearly distinct but often confused with verification and monitoring which are also major requirements of the Preventive Control rules under FSMA. The PC Rules define verification and monitoring as follows:

Verification: 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.

Monitoring: To conduct a planned sequence of observations or measurements to assess whether control measures are operating as intended.

The FSMA regulations further require that all activities related to planning, conducting or evaluating the results of the validation be overseen by a Preventive Controls Qualified Individual (PCQI). The PCQI is defined in the rule as 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."

What do we validate?

Validation in the context of microbial control through a pasteurization or sterilization step refers to demonstrating that a combination of various process parameters (i.e. time and temperature) is sufficient to eliminate a microbial hazard. Microbial control measures involving pasteurization/validation may be applied to:

1. A food product or ingredient
2. Packaging equipment surfaces (product contact or aseptic zones)
3. Packaging environment atmosphere (i.e. sterile air used to maintain positive pressure in aseptic systems or sterile nitrogen added to headspace of containers or sterile water used to cool down product contact surfaces in certain applications)
4. Food containers
5. Food container closures

It is important to note that validation is specific to the intended product, process and process parameters being evaluated. For example, in aseptic processing, packaging materials (bottles and closures) are often sterilized with hot hydrogen peroxide prior to filling with pre-sterilized beverages. Table 1 provides a sample list of the critical process parameters and associated critical limits used in the sterilization of such material.

Table 1. Some Critical Process Parameters and Associated Critical Limits

Sterilization Parameters	Critical Limits
H2O2 concentration	≥32%
H2O2 temperature	≥58°C
Machine speed (sterilization time)	≤200 container per minute

A validation of the sterilization process above would be specific for the bottle size, shape and composition as well as the sterilization system and sterilization parameters listed above. Following sterilization any change in any of the above will require an evaluation by a qualified authority and likely will result in the need for revalidation.

Kinetics of Microbial Destruction – Selecting the Microbial Target

The hazard analysis mandated by FSMA regulations serves to identify the pathogens of significance for a specific food and its specific process or control measure. Food safety control measures are designed to eliminate or reduce the microbial safety risk in a finished food product. There are many pathogenic microorganisms capable of causing human illness if present in a food product. Therefore, the validation of a control measure must focus on the elimination of the most resistant pathogen of significance (pertinent organisms) for the given product and process.

For example, *Clostridium botulinum* has long been recognized as the most resistant pathogen of significance in low-acid, canned foods. The reasons for categorizing this organism as such include:

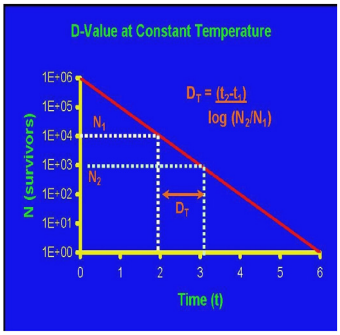
1. It produces the most potent biological toxin known
2. It grows best in the oxygen-deprived environment inside cans (strict anaerobe)
3. It produces highly heat-resistant spores which could survive a poorly designed or executed thermal process

Conversely, the same organism is not considered as a significant pathogen in high-acid products (pH≤4.6) or low-moisture products (aw≤0.85). In these types of foods the spores of *C. botulinum* are not capable of germinating and producing their lethal toxin due to the intrinsic parameters (i.e. acidity) present in these products.

As mentioned above, the spores of *C. botulinum* are extremely resistant to thermal inactivation (retort) processes commonly used in the canning industry. Understanding the resistance of a microorganism to a given process technology (e.g. thermal, high pressure, chemical, etc.) is essential to identifying the microbial target prior to conducting the validation. Destruction of microorganisms as a function of a thermal sterilization process normally proceeds as a geometric progression following first order kinetics of inactivation. The resistance of microorganisms to thermal inactivation is normally expressed in the form of D and z values.

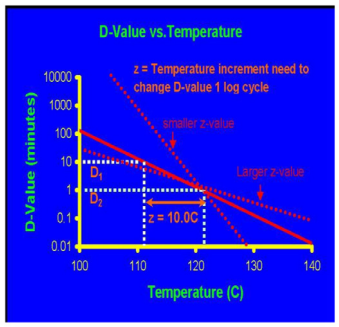
The D value is defined as the time in minutes at a constant temperature necessary to reduce the microbial population by 90% (1 log cycle). It can be determined experimentally by conducting thermal death time studies for a given organism in a specific matrix. Figure 1 graphically and mathematically illustrates the concept of the D value.

Figure 1: Graphical and Mathematical Illustration: D value



The z value is defined as the change in temperature necessary to bring about a 10-fold (1-log) change in the D value. Figure 2 graphically illustrates the concept of the z value (thermal death time curve).

Figure 2. Graphical and Mathematical Illustration: z-value



The D value for *C. botulinum* spores in many low-acid foods at a temperature of 121°C (250°F) is approximately 0.21 minutes. Therefore, it takes approximately 12 seconds at 121°C to reduce a population of *C. botulinum* spores by 90% or 1 log cycle. Conversely, the z-value normally associated with spores of *C. botulinum* in low-acid, high-moisture environments is 10°C (18°F). Thus, a decrease in temperature of 10 degrees from 121°C down to 111°C results in an increase in D value from 0.21 min to 2.1 min (a 10-fold increase).

In contrast to the spores of *C. botulinum* populations of non-spore-forming pathogens such as *Salmonella, Listeria monocytogenes* and *E. coli* would be reduced by thousands of logs if exposed to the same sterilization conditions. Spores of other spore-forming pathogenic organisms such as *Bacillus cereus* and *Clostridium perfringes* are also orders of magnitude less resistant than *C. botulinum* spores. Therefore, *C. botulinum* is considered the microbial target for retort processes intended for low-acid canned foods.

As explained above, *C. botulinum* is the microbial food safety target in most applications involving low-acid, shelf-stable products as it produces the most resistant spores to almost all of the sterilization technologies used in this category. An exception to this rule occurs when peracetic acid is used as a sterilant for plastic bottles in low-acid aseptic filling applications. Table 2 shows various sterilants used in low-acid, shelf-stable applications and the microbial safety target identified for each of them.

Table 2. Some Sterilants and Microbial Safety Targets (Low-Acid, Shelf-Stable Applications)

Sterilization Agent	Microbial Target / Food Safety
H2O2	*C. botulinum*
Vapor H2O2	*C. botulinum*
Saturated Steam	*C. botulinum*
Dry heat	*C. botulinum*
Peracetic Acid (PAA)	*Bacillus cereus*
Electron Beam	*C. botulinum*
Gamma radiation	*C. botulinum*

The high resistance of *B. cereus* to widely used peracetic-acid-based sterilants is well documented in the scientific literature. Blakistone, *et al.*, reported that *B. cereus* was significantly more resistant to PAA than other spore-forming bacteria including *C. botulinum*. This author reported *B. cereus* strain N1009 as the most resistant strain found among those tested. Work conducted at Covance confirmed these findings and furthermore reported strain N1127 to be even more resistant to PAA sterilization than N1009. Table 3 shows the results of that study.

Table 3. Resistance of spores of various *B. cereus* and *C. botulinum* strains to sterilization with 4,100 ppm PAA at 58°C (adjuvant at 1,200 ppm).

Organism	D value (sec)	Organism	D value (sec)
B. cereus N1127	4.82	*C. botulinum* 56A (p)	<1.42
B. cereus N1051	2.32	*C. botulinum* 62A (p)	<2.24
B. cereus N1009	2.26	*C. botulinum* 69A (p)	<2.39
B. cereus N1012	2.13	*C. botulinum* 77A (p)	<2.48
B. cereus N1028	2.11	*C. botulinum* 90A (p)	<2.07
B. cereus N2101	1.47	*C. botulinum* 4B (p)	<1.44
B. cereus ATCC10876	<2.19	*C. botulinum* 53B (p)	<2.33
B. cereus ATCC14579	<2.06	*C. botulinum* 113B (p)	<2.20
B. cereus N2103	<2.00	*C. botulinum* 213B (p)	<2.09
B. cereus N2100	<1.31	*C. botulinum* Lamanna B (p)	<2.16
		C. botulinum Kapchunka B (np)	<2.44
		C. botulinum 2129B (np)	<2.14

The information presented above illustrates the importance of understanding microbial inactivation kinetics and microbial growth requirements in selecting the appropriate target for a sterilization or pasteurization process. The identification of a microbial target for a given process should be done by a qualified authority possessing good understanding of the ability of a given organism to grow or survive in a given product, the severity of the illness it

produces, the intended use of the given product and the resistance of the organism to the specific control measure being validated. In many cases, some or all of this information may not be readily available in the scientific literature. In such cases, extensive research work (thermal death time studies, challenge studies, etc.) may be needed prior to identifying the correct microbial target.

When to validate?

Microbiological validation is conducted when a control measure is initially implemented. The objective is to demonstrate that the critical limits established for the given control measure are capable of providing the necessary microbial lethality. Any change in these parameters following validation may require revalidation. In the case of products under the requirements of FSMA's PC Rule, the need for revalidation should be evaluated by a Preventive Controls Qualified Individual. A very helpful tool on evaluating the need for revalidation is access to records detailing the methods and test parameters used during the original validation and records of all changes that have taken place since the validation. This need illustrates the importance of properly documenting the validation process and implementing a properly designed Management of Change Control Program (MOC). The MOC should provide for a proper numerical/chronological classification of all changes introduced into the processing system and require review and signature by supervisory personnel and a competent authority prior to implementation of the change.

Defining the Validation Criteria

The first step in selecting a validation or performance criteria is to define the Food Safety Objective (FSO) the control measure is intended to deliver. The use of FSO in evaluating alternative pasteurization processes has been recommended by the National Advisory Committee on Microbiological Criteria for Foods (NACMCF). Following the example of *C. botulinum* in the canning and aseptic processing industry, the FSO for the thermal process applied to a low-acid canned food (LACF) is to provide a Probability of a Non-Sterile Unit (PNSU) equal to or greater than to 1 non-sterile unit in 10^9 total units for the microbial target, *C. botulinum*. Parting from this requirement and the conservative assumption that unprocessed units may contain up to 10^3 spores of *C. botulinum* per unit, a performance criteria in the form of a target log count reduction (LCR) can be calculated mathematically as illustrated below.

Calculating a target lethality or LCR (Y):

Where:

$$Y = \log No - \log NF$$

No = Initial spore load; and NF = number of survivors

If a PNSU of 10^{-9} is desired and a maximum initial load of 10^3 spores per unit is expected, then:

$$Y = \log 10^3 - \log 10^{-9}$$

$$Y = 3 - (-9) = 12 \text{ logs}$$

Therefore, the control measure applied to mitigate the risk of *C. botulinum* intoxication must deliver a 12 log reduction of the pathogenic spores of this organism. Given our understanding of the heat resistance of *C. botulinum* spores, a thermal process can be mathematically calculated to deliver this target as follows. It is widely accepted that the D value of these spores at 121°C is 0.21 minutes. Therefore, it takes 0.21 minutes to reduce the population by 1 log cycle (90%). If a 12-log reduction was desired, the process time (Pt) at 121°C can be calculated:

$$Pt = D_{121C} \text{ x target log reduction } Pt = 0.21 \text{ min x } 12 \text{ logs} = 2.5 \text{ minutes}$$

Also, since we know the z value for this organism is 10°C, an equivalent process can be calculated at various temperatures. For example, if the process temperature is reduced by 10°C the process time would have to increase by a factor of 10 to 25 minutes.

In summary, in this example we have calculated a target lethality of 12 log reduction for the spores of *C. botulinum* to use as validation criteria in a retort type process for a low-acid canned product.

The Validation Approach

Once validation criteria are established, the approach to demonstrate that the control measure is capable to deliver the desired outcome must be selected. Codex Alimentarius lists a number of approaches to validate a microbial control measure. Among these:

1. Reference to scientific or technical literature, previous validation studies or historical knowledge
2. Scientifically valid experimental data that demonstrate adequacy (microbial challenge study)
3. Collection of data during operating conditions in the whole food preparation
4. Mathematical modeling

Reference to technical literature and historical knowledge is extensively used in the establishment of retort processes for low-acid canned foods. On the other hand, microbiological challenge testing using surrogate organisms is widely used for the validation of aseptic fillers and more recently for the validation of low-moisture products processes like roasting, drying, extrusion and baking. Collection of data during operation is a validation approach mostly applied to situations when there is no definitive kill-step in the process. Mathematical modeling has been applied as part of the validation for thermally processing fluid products containing particulates (e.g. potato soup) aseptically.

As a result of the regulations mandated by the Food Safety Modernization Act, many companies have initiated work to validate a variety of different processes for numerous products. Many of these processes have never been validated in the past and no validation approach or strategy has been established for this purpose. At Covance, we start every one of these new validation projects by conducting a literature search and developing a strategy for validating the process which may use any one of the above-mentioned approaches. However, the most common approach is to conduct a microbial challenge test using a surrogate organism as described in the next sections of this document.

Use of Microbial Surrogates for Process Validation

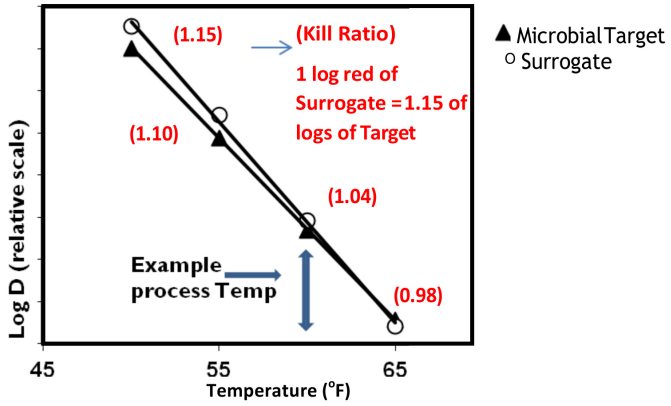
As stated previously in the context of this document, the objective of microbial safety validation is to demonstrate that a given control measure is able to deliver the intended microbial destruction result. The intended result is often measured in the form of a desired log count reduction (LCR) of the microbial target established for the product/process. Thus, a microbial challenge of the sterilization technology at the point of use would be the ideal experimental approach in instances when the control measure cannot be adequately simulated in the laboratory. However, a pathogenic organism should not be taken into a food plant or other uncontrolled environment. Therefore, a surrogate organism is often necessary to test the sterilization technology at the plant level when no other alternative method (i.e. direct temperature measurements or laboratory simulation) is possible.

An ideal surrogate displays the following characteristics:

- Non-pathogenic
- Resistance is quantitatively correlated to target (destruction kinetics – D and z values)
- Correlation to target is valid through range of treatment
- Correlation to target allows for practical use in terms of surrogate concentration needed for work
- Can be prepared as a stable suspension
- Each crop is calibrated prior to use
- Possess distinct metabolic or morphological characteristic(s)

Figure 3 shows a sample illustration of the resistance correlation between *B. cereus* spores and a surrogate organism to sterilization with a peracetic-acid-based sterilant. The sterilization curve for both organisms depicts their correlation as the process moves from one temperature to another. As can be seen in the graph, the correlation is nearly 1:1 throughout the temperature range depicted. Therefore, the example represents an ideal correlation between a surrogate and the target organism throughout a range of operating temperatures. In actual practice it is extremely difficult to find surrogate organisms that fit all the criteria listed above and that closely correlate with the process resistance of the target. However, once a proper surrogate organism is found it can serve as an invaluable tool in validating pasteurization and sterilization processes.

Figure 3. Example of thermal death time curves for sterilization of spores of *B. cereus* and a potential surrogate using peracetic acid (4,000 ppm) at various temperatures.



Executing the Microbial Challenge Validation Using a Surrogate

Once the mathematical correlation between destruction of the microbial target and the surrogate has been established, the validation study can be designed. When developing the experimental protocol, careful attention should be given to the following:

1. The validation team
2. Inoculum preparation
3. Inoculation procedures
4. Test parameters
5. Test matrix (product, equipment or package)
6. Recovery of survivors and enumeration procedures
7. Log reduction calculations
8. Proper documentation of validation procedures, test parameters and results (final report)

The validation team: Food processing systems intended to provide sterilization or pasteurization processes are complex in nature. Thus, designing and evaluating a system intended to deliver a food safety measure requires understanding of multiple scientific and engineering disciplines. A validation team should be assembled that includes as a minimum, representative(s) of the processing equipment manufacturer, the processing facility and processing authority. The team should cover the following disciplines and functions:

1. Process equipment computer software controls
2. Engineering (equipment design, electronics, control logic, alarms and interlocks)
3. Product development (understanding of formulas and product intrinsic parameters as well as expected variability on these parameters and ingredient type and sources)
4. Chemistry (understanding of chemical sterilants and preservatives)
5. Microbiology (understanding of microbial targets and surrogates used)
6. Regulatory compliance
7. Equipment maintenance

Inoculum preparation: The inoculum (surrogate) used for the validation should be prepared in the same way as it was prepared during the calibration procedures used to establish its correlation with the target organisms. In the case of surrogates consisting of vegetative cells, attention should be given to the inoculum growth phase (i.e. lag, stationary or death phases), media used to grow the surrogate, growth temperatures, acid adaptation (if applicable), etc. In the case of surrogates consisting of spore suspensions, every crop of spores should be checked for adequate resistance prior to use. In all cases, the concentration (initial number) of surrogate spores/cells should be confirmed by collecting and analyzing a sample of the inoculum suspension as used in the validation.

Inoculation procedure: The surrogate must be introduced into the test matrix in a way that does not alter the normal composition and attributes of the matrix. For example, in the case of low-moisture products, special care must be given to ensure that the surrogate inoculation procedure does not increase the water activity of the matrix. In the case of validation of packaging material sterilization in aseptic applications, samples can be inoculated with surrogate spores by either the “spot” or “spray” technique. The spot inoculation consists of depositing a single highly concentrated aliquot of the spore suspension on the sample and allowing it to air dry. In the spray technique

the sample is dispersed in small droplets (sprayed) over a larger surface. A major concern of the spot inoculation technique is that the highly concentrated spot could result in layering of spores that would create a more difficult sterilization challenge than normally found in the actual production environment. This issue is magnified in package material sterilizations that rely on chemical sterilants of limited penetrating ability such as vaporized hydrogen peroxide. However, the net effect of this experimental artifact is a more conservative assessment of the technology, so from a food safety standpoint this is of no concern. On the other hand, the spray technique presents the challenge of accurately dispensing a measured volume of spore suspension over a defined area. Both techniques present advantages and disadvantages depending on the various applications, so an experienced processing authority should be consulted in choosing the appropriate inoculation technique.

Test Parameters (Process): While it is not always possible and advisable to reduce all critical process parameters to their minimal condition (worst case), the validation testing must represent a conservative sterilization condition relative to normal operating conditions. In many cases sterilization conditions are automatically controlled. In such cases alarms and interlocks may have to be bypassed to achieve minimal sterilization conditions. To accomplish this task it is important to have present representatives from the equipment manufacturer who are familiar with the software of the programmable logic controller (PLC) and who are capable of making the necessary adjustments before testing, as well as returning the system to its normal operation settings afterward. Ideally, the test parameters used during the validation will become the critical limits for the process. These test parameters may also serve to evaluate process deviations during operation in the future.

Test Matrix (Product): The sterilization matrix is also of critical importance in the validation process. For example, in the case of thermally processed low-moisture foods, the product matrix must represent the lowest possible water activity expected during normal production. This is the case because microbial resistance to thermal inactivation is inversely proportional to the water activity. In other words, microbes are more resistant to heat inactivation in drier environments. In many cases the water activity of the product changes during the process. In these cases it is very important to understand the moisture gradient during the process so that a conservative representation of this gradient can be used during the validation. Among the test matrix (product) parameters that may need to be considered during a validation are:

1. Water activity
2. Moisture
3. Presence and concentration of preservatives (i.e. sodium benzoate, potassium sorbate, nisin, etc.)
4. % Salt
5. pH
6. Oxygen concentration
7. Chemical composition (in packaging material sterilization)

Recovery of Survivors and Log Count Reduction Calculations (LCR): Following exposure of the inoculated test matrix to the sterilization process, the surviving organisms must be recovered and enumerated. There are two common methods used to recover and enumerate surviving microorganisms in microbial validation studies: the count reduction method (CRM) and the end-point method. Highlights of each of these methods are shown in Table 4.

Count Reduction	End Point
Test organism is enumerated using plating methods after treatment	Treated samples are analyzed for growth/no growth (binomial data)
Single inoculum level is used	Multiple inoculum levels used
Inoculum level is higher than desired LCR (i.e. for a 4 LCR, a 106 cells/sample is used)	Inoculum levels bracket the desired LCR (i.e. for 4 LCR, 10^3, 10^4, 10^5 cells/sample are used)
Approx. 10-25 samples per treatment/ inoculation level/test replicate	Approximately 100 samples per treatment/inoculation level/test replicate
Number of survivors is calculated arithmetically based on results of plating methods	Average number of survivors is calculated statistically based on number of samples showing growth

Regardless of the method used, the microbiological media used to recover survivors is of critical importance. Non-selective media is preferable to recover survivors as selective agents added to media often reduce the recovery rate of survivors. However, in many instances pasteurization processes result in inactivation of vegetative pathogens but spores of other bacteria remain in the product and could interfere with the detection of surviving cells/spores of the test organism (surrogate). In these instances differential compounds (i.e. chromogenic substrates) may be added to assist with the detection of survivors or, in more extreme cases, selective compounds will be needed to assist with the interfering background microflora. If selective compounds are used, preliminary work should be conducted in the laboratory to confirm that the addition of selective agents have not detrimentally affected the pre-established correlation between the surrogate and target organism.

In case of the count reduction method, survivors must be retrieved from the test matrix and resuspended in a diluent in preparation for enumeration plating. Once the number of survivors is estimated, the log reduction can be calculated by simply subtracting the log of the number of survivors from the log of the initial number of test (surrogate) organisms.

For the end point technique, the test matrix is analyzed for the presence of organisms in multiple samples and the log reduction can be calculated based on the number of units that test positive for surviving test organisms. For example, the average log reduction can be calculated by applying the Halvorson-Ziegler equation (*J. Bacteriology,* vol. XXV, No. 2, 1932) as follows:

$$X = \ln(r/q)$$

Where:

X = average number of viable spores per inoculation site surviving the treatment. r = the number of units tested

q = the number of units that were sterile following treatment

The log reduction resulting from the treatment is then calculated as follows:

$$\text{Log reduction} = \log a - \log b$$

Where:

a = the initial spore concentration

b = the final spore concentration (X).

Once the log reduction for the surrogate is calculated it can be converted to the theoretical log reduction of the target pathogen(s) using the pre-established correlations between surrogate and pathogen. It can then be determined if the control measure meets the accepted criteria and thus the desired Food Safety Objective.

Documenting the Validation:

It is essential to document the whole validation process. This is necessary for a variety of reasons including:

1. Provision of evidence of the efficacy of the process to regulatory agencies.
2. Assessing the need for revalidation in the event of changes to the process.
3. Evaluation of process deviations.
4. Assessing the impact of new scientific discoveries on the validation process.

The documentation collected should include:

1. Detailed description of the process including necessary piping and instrumentation diagrams (P&ID), operational logic and alarms.
2. List of critical factors.
3. Scientific justification for the validation approach used.
4. Microbiological study report supporting the use of microbial surrogate.
5. Validation study report including laboratory work in preparation of microbial surrogates and analyzing samples from on-site validation.
6. Documentation of actual test parameters (charts, printouts, manual notations, etc.) used during the validation tests.

When to Revalidate:

In our experience, much debate around the need for revalidation is fueled by misunderstanding between validation and verification. It is often stated that revalidation should be performed as a function of time. For example, some major companies conduct process validations on a periodical (i.e. biannual) basis. The justification for this approach is to confirm that the process continues to operate as originally established and validated. As previously stated in this document, the objective of validation is demonstrating that a given set of processing parameters applied to a specific matrix results in a desired result. For example, validating that a processing system programmed to deliver a process of 160°F for 1 minute is sufficient to inactivate *Salmonella* in Formula x beverage with a maximum pH of 4.2. Once these process parameters are validated there is no need for revalidation unless a critical process parameter is changed, the processing system is redesigned or new scientific evidence is obtained that changes the original assumptions or identifies a new hazard. The need for periodical checks of the process function is verification, not validation.

As a final note, it is imperative that whenever a change is incorporated to the processing system which may impact the critical process parameters, a qualified processing authority be consulted to determine if revalidation is necessary.

Covance Can Help

The experiences and capabilities of Covance in the validation and verification of thermal processes designed to provide microbiological safety of foods are deeply rooted in our food safety heritage. True to its heritage, Covance continues to develop better and more efficient methods to accomplish these tasks, not only for the canning industry but also for many other sterilization and pasteurization processes used for a variety of food and beverage products and target microorganisms. Our team of microbiologists and processing engineers possess many years of experience in the validation of thermal and non-thermal process applied to beverages and foods across the industry. And, we have also served as a recognized Processing Authority by the FDA and the USDA for more than 30 years.

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