Validation of cleaning

Thorough cleaning is a crucial prerequisite to sound hygienic conditions in any food manufacturing environment. Cleaning protocols must be validated in order to provide assurance that they do, in fact, serve their purpose: to clean the surfaces to a level that avoids the possibility of cross-contamination. In relation to food production, the main cross-contamination hazards are physical, chemical, biological and allergenic. Depending on the products intended consumers, the process and procedure for the control of the hazards may vary significantly.

According to the BRC Food Safety Global View 2015, analysis of audit data, sampled from 17,113 sites in 2014, has enabled identification of vital trends relating to food safety and hygiene in food production worldwide. The most frequent non-conformities that emerged globally were concerned with Documenting Cleaning Procedures (Clause 4.11.1), with 18.3% prevalence across all sites, followed by Door Maintenance (Clause 4.4.9) and Chemical Control Processes (Clause 4.9.1.1). In particular, Housekeeping and Hygiene (Section 4.11) presented the most problematic set of criteria, suggesting that all categories' sites needed to improve the maintenance of their housekeeping and cleaning systems.

This paper discusses the development of a cleaning regime, deciding the level of clean required by assessment of the product risk and process, how to validate the cleaning regime, and sampling techniques used to validate the efficiency of a cleaning procedure.

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National and international legislation requires the food industry to ensure that food placed on the market is safe. EC/178/2002 states that the products should not be injurious to health or unfit for human consumption, whilst the Machinery Directive (EC Directive 2006/42) requires that equipment manufacturers should provide cleanable equipment. When looking at external accreditations, section 5.3 in the BRC Global Food Standard version 7 specifically relates to management of allergens. In particular section 5.3.8 states that *"Equipment or area cleaning procedures shall be designed to remove or reduce to acceptable levels any potential cross-contamination by allergens. The cleaning methods shall be validated to ensure they are effective and the effectiveness of the procedure routinely verified. Cleaning equipment used to clean allergenic materials shall either be identifiable and specific for allergen use, single use, or effectively cleaned after use."*

The purpose of cleaning validation is to demonstrate that a specified, documented cleaning regime is capable to a predetermined limit, directing the activity towards ensuring that food is safely produced. The verification provides a quality control method to determine the effectiveness of a cleaning process for a specific cleaning event. Verification can be carried out on a regular basis and if results are found to be out of specification, actions can be made immediately to rectify the problem. Cleaning validation and verification may be carried out on many items, depending on the risk to the product, including equipment, personnel and protective clothing identified as potential sources of cross-contamination.

This report coincides with the release of Document 45 – Part 1 entitled *'Cleaning validation in the food industry - general principles'* from the European Hygienic Engineering Design Group (EHEDG, 2016). EHEDG was set up to provide best practice guidance on hygienic engineering and design for food equipment manufactured in or imported into Europe. Its network of experts disseminates knowledge on the design, installation and cleanability of components and also helps to specify best practices for hygienic operations, supply and maintenance. The cleaning validation document was designed by several experts in the field (examples include representatives from food and chemical manufacturers, consultants and universities) and provides a step by step guide on how to undertake and report a cleaning validation within the food industry.

Cleaning validation

Cleaning validation has been widely used in the pharmaceutical industry. In 1988 the FDA raised concerns over a company producing a bulk pharmaceutical chemical contaminated with low level ingredients from the production of agricultural pesticides. The cross-contamination was believed to be due to the reuse of recovered solvents that had been contaminated due to lack of control over the reuse of solvent drums. The issue was significant and posed a serious health risk to the public. The FSA later set up standards and guidelines on best practice for the pharmaceutical and food industry, in order to avoid cross-over from one process to another via poor cleaning processes.

Recently published, Document 45 - Part 1, from EHEDG (2016), defines cleaning validation as *"Obtaining the documented evidence that cleaning with or without disinfection processes, if properly implemented, is consistently effective at achieving a predefined level of hygiene on product contact surfaces identified during the hazard evaluation."*

For clarity it is important to know the difference between validation, monitoring and verification, as they are commonly confused:

- **Validation** is obtaining proof through the provision of objective evidence that a control or measure, if properly implemented, is capable of delivering the specified outcome.
- **Monitoring** is defined, in ISO 22000, as "*conducting a planned sequence of observations of measurements to assess whether control measures are operating as intended.*"
- **Verification** is defined, in ISO 22000, as "*confirmation, through the provision of objective evidence, that specified requirements have been fulfilled.*"

When developing a cleaning regime and validation, the first steps involve understanding the item to be cleaned, the risk to the product, and the chemicals to be used. It is important to identify the hazards. This may involve ensuring that equipment has been suitability designed for cleaning, for example it is drainable and the chemicals used will not have a detrimental effect on the surface. Assessing the design may include finding dead legs, where food debris or microorganisms can harbour, thereby decreasing the full impact of the cleaning process.

An understanding of the food and process is important in order to identify the degree of cleanliness that is required. This may take into consideration the food safety level expected in the end product; for example, if the product is ready-to-eat and microorganisms will not be removed via any heating step before eating, controls must be in place in the factory to ensure that only safe food reaches the end consumer. It is essential to know the ingredients and possible cross-over risks between batches of, for example, allergens, DNA, and microbiological or chemical residues. In this case, the timing of cleaning is important and needs to be defined, documented, controlled and monitored. Details about the method, cleaning agents, contact time and monitoring methods must be available and adhered to.

Developing a cleaning regime

There are many factors that come into play when developing a cleaning programme; for example:

What are you cleaning? i.e. materials of construction, size of object, area where the equipment is installed, design and accessibility and can they withstand the conditions of certain chemicals? Also **what** debris is to be removed and **what** are the risks if the debris are not removed?

Where are you cleaning? high risk, low risk, aseptic etc. Some parts may be removed and washed in a separate area (cleaning out of place - COP) or cleaned in place (CIP). When cleaning in specific rooms, is the clean and dirty equipment fully segregated?

When is cleaning carried out? depending on risk and frequency of product change over, the cleaning times may be hourly, daily or weekly. Is this a routine clean or a deep clean? Cleaning may be during production or out of production, which may impact the spread of contamination during cleaning.

Why are you cleaning? to remove food debris, allergens, or prevent microbial or chemical build up?

Finally how? This relies on firstly answering the above questions. When it comes to **how** the methods are also important to question:

- High pressure air or water results in the movement of debris and dirt. It is important that these actions are controlled (again depending on risk) as studies have found that high pressure water can transport contamination from point of source as far as 4 m high and 7 m away from the cleaning area. This has the potential to contaminate surfaces of equipment in wide open spaces.

It brings back the question **where** are you cleaning? If production lines are still running there is a large risk of cross-contamination spreading to open product in the area from the cleaning operations.

• Floor scrubbers and other mechanical cleaning apparatus, if used, need to be controlled, cleaned and maintained regularly. If not cleaned sufficiently they may only spread contamination around.

• Steam cleaning methods have become more popular for cleaning applications and have interests in the dry food industry in relation to controlled wetting. The suitability of this method for the surfaces is important to consider to avoid damage to the facade.

Cleaning incorporates 4 main factors: chemical, mechanical, time and temperature in varying amounts depending on the method used (i.e for CIP it is mainly chemical and temperature as opposed to mechanical, using liquid flow to achieve some mechanical benefits; in contrast, manual cleaning incorporates more mechanical action). Validation is confirmation that the method meets the requirements for a specific intended use - that is, that the method is fit for purpose.

Deciding the level of clean

Advice from the APIC (Active Pharmaceutical Ingredients Committee, 2014) recommended that at least three levels of cleaning in the production of a commercial product may be implemented. They use the approach outlined in Table 1; however, they state that additional levels might be necessary depending on the nature of the process and requirements of individual companies. Just as in the food industry these should always be based on risk assessment, where the characteristics of the previous and subsequent products such as solubility, nature of residues, and process step, etc. should be considered.

Table 1: Levels of cleaning advised by APIC (2014)

Level	Thoroughness of cleaning	Risk	Verification		Validation
			Visual	**Analytical**	
2	Carryover of the previous product is critical. Cleaning required until predetermined stringent carry over limits are met.	High	Yes	Yes	Mandatory
1	Carryover of the previous product is less critical. Cleaning should reduce the potential carry over to a less stringent limit as required for level 2.	Medium	Yes	Yes	Recommended
0	Only gross cleaning if carryover of the previous product is not critical.	Low	Yes	No	No

Validating the cleaning regime

The cleaning validation involves a series of stages over the lifecycle of the product and cleaning process. The first stage involves process design. This requires evaluation of the chemical and physical properties of the residue, determining the most difficult to clean residue and evaluating the residue's solubility and stability. The next stage involves demonstrating that the cleaning procedure works as expected, determining the type of cleaning to be used (e.g CIP, manual, etc) and the control parameters (e.g. temperature, flow rates, pressure, etc.) required. It also assesses where the most difficult to clean locations are and how to train operators. Cleaning validation does not stop there, as there needs to be a continual assessment of the cleaning in the form of verification and monitoring. The cleaning process should remain in control throughout the product lifecycle and if elements of the cleaning process changes then re-validation should be carried out.

Cleaning validation can be based on either one of two methods: one based on evidence obtained through testing and one based on the analysis of historical data (retrospective validation). Validation through testing is preferred and may include challenge or worst-case tests, which determine the robustness of the cleaning process. It can be considered as a three step process, involving firstly cleaning and rinsing of the surfaces, sampling any residues that might still remain on those surfaces and analyzing the sampled materials with the appropriate methods.

In order to validate a cleaning regime it is vital to determine/quantify *'how clean is clean'*, in other words know the acceptance criteria. This may be measured in CFU/ml for microorganisms or $\mu g/cm^2$ for organic matter or allergens. In the case of pathogens and allergens, absence is usually required on food contact surfaces after cleaning. Another method that can be utilised is ATP (adenosine triphosphate) swabbing. This measures the amount of residual organic matter on a surface. Depending on the food produced, different processing industries and surfaces will have variations in acceptable levels. For example, ATP levels may be much higher in a fresh fruit preparation facility as opposed to a bakery due to the nature of the product. ATP monitoring is a common rapid testing method used by food and beverage processors to quickly assess the cleanliness of surfaces or liquid samples. Pass and fail limits of 'clean' should be determined by the facility and documented as to how they were determined. The percentage reduction in soiling from dirty to cleaned surfaces can be used as an indicator of cleanliness.

Once the cleaning regime has been established, one can set up a suitable soiling procedure to assess the efficacy of the clean to remove a worst-case contamination. This involves soiling a surface with a known contaminant (be that microbial, allergen or organic matter) and cleaning using the protocol defined. The cleaned surface would then be sampled to assess the reduction in contamination that would be worst-case scenario. The assessment is best carried out in difficult to reach areas or rough surfaces that may harbour microbial, allergen or organic matter. Advice from EHEDG (2016) suggests that a minimum of three consecutive trials that meet the validation objectives are required for a successful validation. If any test does not meet the validation objectives the validation process must be stopped and the cleaning procedure and validation protocol reviewed. Often, the locations that are the hardest to access will have to receive special attention to assure that they have been cleaned sufficiently.

To determine the degree of cleanliness this, in first instance, could be carried out via visual analysis; however, many systems in place do not provide the luxury of seeing all food contact surfaces. Also much of the contamination that may be on the surface may not be visable to the eye, so must be measured via other methods such as chemical, microbiological or allergenic residue testing.

It is very important to highlight that a change in process, product and cleaning regime requires a re-validation, which should follow the same steps as the initial validation.

Sampling techniques used to validate the efficiency of a cleaning procedure

The major sampling methods for cleaning validation are swabbing, contact plates, rinse sampling and placebo sampling. An evaluation of the effectiveness of cleaning can be carried out by adding dye to product surrogates, then swabbing the surfaces and analysing the swab for traces of the dye or by testing for unmodified product residues or detergent residues (Cooper, 1997). When using surrogates, the closeness to the original product is vital. Using swabs has the advantage of physical removal of contaminants, whilst sampling rinse water can deal with a larger area and reach otherwise inaccessible areas. Both, however, may not have the required removal efficiency. When sampling rinse water the whole equipment surface is rinsed with a known volume of water and solvent; a representative, homogeneous sample must be taken. In relation to placebos, water, glycol or starch are used to sample encapsulation, mixing or tabletting machinery in the medical industry.

Other methods can be carried out to verify suitability of the cleaning chemicals, such as conductivity measurements to assess the detergent concentration, alkalinity tests or measurement of the concentration of complexing agents. Protein residual measurements are also a common method to assess proteinaceous debris removal. More complex methods can be used to monitor the efficiency of a cleaning process such as PCR measurement (Polymerase Chain Reaction), TOC-analysis (Total Organic Carbon), HPLC, GLC and GC (common chromatography methods used in analytical chemistry) and immunochemistry analysis such as ELISA (method based on analysis of antibodies and antigens) or SDS PAGE : determination of pyrogens and denatured proteins.

Cooper (1997) suggests that a typical cleaning validation study may employ pH, conductivity, total organic carbon (TOC), detergent assays and a product-specific assay. Analyses should be compared for precision, accuracy, detection limits, quantification limits, selectivity, linearity, range and sensitivity.

Conclusion

Cleaning validation is a vital part of hygiene prerequisite control within the food industry. It provides confirmation of reproducibility of not only CIP systems, but also manual cleaning procedures. It can lead to improvements in the level of food safety and reduce liability by showing due diligence. It shows confirmation of the removal of allergens, product residues and cleaning solutions.

As mentioned earlier, Housekeeping and Hygiene (Section 4.11) was one of the main issues in relation to non-conformances in BRC audits in 2014 (BRC, 2015). Section 4.11 states: "*Housekeeping and cleaning systems shall be in place which ensure appropriate standards of hygiene are maintained at all times and the risk of product contamination is minimised.*" In particular clause 4.11.1, documenting cleaning procedures, was most prominently overlooked. It has been said that if something isn't recorded there is no proof that it has taken place. Sound documentation is important in order to show that there is validated evidence that correct practices have been chosen in relation to cleaning.

Verification and monitoring can be continually used to ensure that the processes are kept in control throughout the lifecycle of both the equipment and the process. Records of these are important for

trending and to provide evidence for due diligence. It is important to develop a suitable cleaning regime, decide the level of clean required by assessment of the product risk and process and use robust validation techniques to prove that the cleaning is reproducibly safe.

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Further reading can be obtained via the following links:
- Validation of cleaning to remove food allergens (Guideline no 59). Copies available at: https://www.campdenbri.co.uk/publications/pubDetails.php?pubsID=2487
- Document 45 – Part 1, Cleaning validation in the food industry- general principles, 2016, accessed online: 14/06/16; http://ehedg.org/uploads/DOC_45_E_2016.pdf

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ISO 22000:2005 Food safety management systems – Requirements for any organization in the food chain

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