DOI: 10.22270/jmpas.2021.V10I6.1927 ISSN NO. 2320–7418

International peer reviewed open access journal

Journal of Medical Pharmaceutical and Allied Sciences

Journal homepage: www.jmpas.com CODEN: JMPACO

Review article

A review on pharmaceutical validation and its implications

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ABSTRACT

Quality is an essential aim of all manufacturing industries and their goods. The present interest in the pharmaceutical sector is in the several viewpoints on attaining such quality and has indeed been maintained by validation. Validation is among the key processes in attaining and preserving the ultimate product quality. Validation of processes stresses components of process design and maintenance of process control throughout marketing. The validation research must demonstrate and record the precision, sensitivity, characteristics and repeatability of the test techniques used by companies. Validation is therefore a crucial component of quality assurance. This study is intended to offer an understanding of the process validation of pharmaceutical products having a particular focus to the US Food and Drug Administration standards (FDA).

Keywords: Quality, Validation, Accuracy, Sensitivity, Repeatability, FDA

Received - 18-09-2021, Reviewed - 11/10/2021, Revised/ Accepted- 30/10/2021

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INTRODUCTION

Any pharmaceutical plant's primary goal is to consistently produce goods with the desired attributes as well as the quality to the lowest possible cost. The pharmaceutical industry is currently interested in a variety of perspectives on how to achieve such a quality. Regardless of the fact that the validation studies for a long time have been conducted in the pharmaceutical sector, there seems to be a significantly growing interest in validation as a result of the industry's greatly increased focus on quality assurance programs in the recent years, and validation is vital to a productive production operation.[1-2]Validation is the process of obtaining confirmation that a technique, procedure, or event utilized in testing and subsequent production maintains the requisite degree of consistency throughout. Since 1978, the concept of validation has been expanding at a rapid pace. Over the years, the notion of validation has broadened in order to include everything from analytical techniques for the control of the quality of all the drug ingredients and the dosage forms to computerized clinical trials platform.[3]One of the most important and well-known cGMP's tool is pharmaceutical process validation. Process validation is the most basic criterion of the quality system (QS) regulations. Process validation includes ensuring and documenting that a process operates within its stated and intended parameters, while ensuring that the manufactured product meets its Pre-determined standards and quality attributes in a consistent and well precise manner. [4]

History of Validation

In the mid-1970s, the two FDA representatives named, Ted Byers and Bud Loftus, introduced the notion of validation to raise the standard for pharmaceuticals (Agalloco 1995). It was specifically designed in response to a number of complications and issues in regard with the sterility of large-volume parenterals. The primary validation procedures had their major focus on the processes that were involved in the manufacturing of these pharmaceutical products, but they quickly spread to associate pharmaceutical processes. The first one to promote for the notion of process validation was U.S.F.D.A, However, no definition of process validation existed in any USFDA literature until September 29, 1978, and no cGMP guidelines referenced it. [5]

Definations

US FDA defination "Process validation is defined as establishment of a documented proof, providing high assurity that a specified process will be continuously producing products that would comply with their pre-defined quality and specification."

ICH defination "Process Validation" as per ICH is defined as "the technique of verifying and giving documented proof that processes under their stated design specifications are well able to generate final products with the best possible quality.

Need of Pharmaceutical Validation

Validation is a crucial aspect of quality assurance, since it entails a thorough examination of the technology,

The equipment's, and activities to see if they are performing their intended functions effectively and consistently. Validating procedures are really important. For a variety of reasons, along with regulatory compliance validation of procedures is necessary. A manufacturer can ensure that all made units will meet specifications and have uniform quality thorough designing and packaging of the device, careful design and validation of procedures, and there by implementing the process control. Validation doesn't really strengthen processes by themselves, however it confirms that the processes have been properly developed and are under control. [6-7]

What Processes Should Be Validated

When inspection and testing cannot fully verify process outcomes during ordinary production, the process must be validated according to established procedures. Process validation is the only realistic way to ensure that processes consistently produce devices that satisfy their planned specifications when any of the following criteria exist: The accuracy of routine final products tests is not enough to ensure the required safety and effectiveness of the end products. To demonstrate that the manufacturing method process delivered the expected outcome or product, clinical or destructive testing would be required. Routine end-product evaluations may not account for all the potential changes in product safety and effectiveness. The capability of the process is unclear, or maybe it is assumed that the process can barely satisfy the device criteria. [8]

BENEFITS OF VALIDATION

- Regularly controlled processes require less process assistance and have less interruption. Batch failures will be reduced, and the company would be able to run more efficiently and produce more.
- In addition to this, quick and effective study results will demonstrate a dedication to quality product that could simplify pre-approval examination and might speed up marketing authorization clearance. [9-10]

Reduced Quality Cost

The cost of the mentioned process will be reduced by performing proper validation.

- Preventive costs are expenses incurred for avoiding failure and lowering the cost of assessment, Cost for inspection, testing, and quality assessment, internal failure.
- External cost of failure resulting from non-compliance following leaving custody of the product to the corporation.

Process Optimization

The facilities, the machineries, and the closures etc. are all being optimized. As a result, a product is obtained that meet its all the quality standards at a very low cost.

Assurance to Quality

The cornerstones of GMPs are validation and process control. Quality products are really difficult to achieve without a validated and controlled process. As a result, validation is an important part of ensuring product quality.

Safety Validation

Can lead to greater safety for the operator. Accidents can be minimized by using, properly validated and calibrated instruments and gauges, thus resulting in safety.

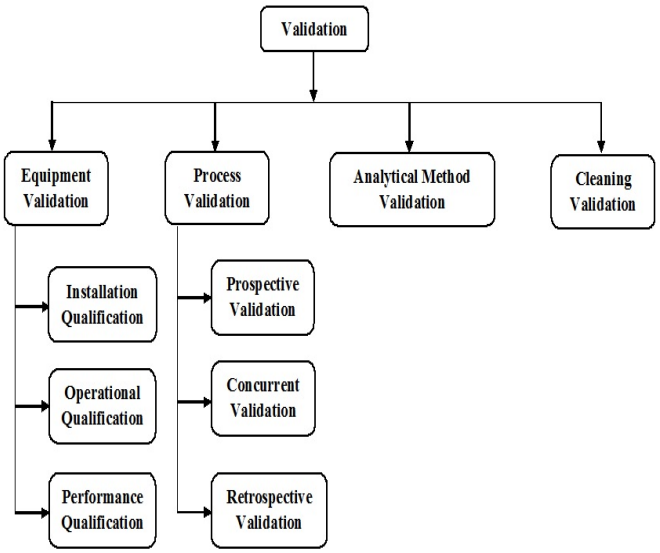
AUTHORITIES RESPONSIBLE FOR VALIDATION

Validation group that is under work is established to plan, analyze, evaluate , progress, collect , organize and finally approve the complete activity, as well as all associated documentation. The following employees are usually included in the working group:

Table 1.-responsible authorities for validation [11-15]

Manager Production	Responsible for manufacturing of batches and review of protocol and report.
Manager QC	Responsible for samples collected
Executive QC	Responsible for analysis of samples collection and submission to QC
Manager Maintenance	Providing utilities and engineering support
Executive Production	Responsible for preparation of protocol and manufacturing of validation batches
Manager QA	Responsible for protocol authorization and preparation of summary report

TYPES OF VALIDATION



Analytical Method Validation

The analytical procedure used for a specific test is validated to ensure that it is adequate for its intended usage. The analytical technique is validated in order to determine whether the method's performance characteristics fulfill the necessities for the given application through laboratory experiments. This implies that the validation of the method can only be established by laboratory testing. Validation or revalidation of methods is required-

- Before their implementation and daily usage;
- When the conditions under which the method was validated

change, such as when the instrument's properties change; and

- When a technique is changed that isn't part of the original procedure's scope.

Analytical Method Validation Advantages

The maximum widespread benefit of any analytical technique validation is that it helps generate trust in both the party i.e the developer and the user. While the validation exercise seems to be high priced and time consuming, it ultimately saves money, eliminates unnecessary repetitions, and improves time management. The following are the five main steps in the validation of a method:

- Qualifying the system
- Sampling
- Sample preparation
- Sample analysis
- Data evaluation

The basic primary goal of the method validation technique is generally to generate evidence that the mentioned method will be performing as it is expected, in terms of accuracy, reliability, and consistency. The validation parameters are listed below, according to the International Conference on Harmonization (ICH) criteria-

a. **Accuracy:** The term "accuracy" is defined as "the degree of consistency across any value that is recognized as standard actual value or an approved set value. To measure accuracy, a minimum of 9 findings across at least of three initial concentrations spanning the prescribed area should be used to determine accuracy. The confidence intervals and the difference among the mean and the recognized standard actual true value, shall be expressed as the percentage of analyte recovery as determined by an assay of a known increased amount of analyte in the sample.

b. **Precision:** It is the of extent of proximity among a set of measures taken from various of the reference solution under specific mentioned conditions. Thus, Precision can be considered on three different levels:

- **Repeatability:** It is also known as intra-assay precision and it measures how accurate a test is under similar operating conditions within a short period of time interval. A total of six replicates of comparable or consistent sample must be available for the 100 percent check.
- **Intermediate precision:** It describes the accuracy in research laboratories on different days, with different analysts, on different instruments and on different equipment's.
- **Reproducibility:** It refers to the consistency of results across different analytical labs; each research facility puts up sets up of a total of six stock solutions depending upon the analytical technique.

c. **Specificity:** The method of analysis should be able to establish specificity, at each level of development stage. When all of the required components, such as few excipients/or the sample matrix, and specimen blank peaks, are present, the technique should be able to evaluate the analyte of interest appropriately.

d. **Detection of Limit (LOD):** The limit of detection of a single analytical process is the least analyte in a test sample which may be identified, although generally not quantified as an accurate number. There are several approaches to determine the LOD, based upon the procedure involved is non-instrumental or instrumental. Other strategies may be allowed in addition to those that are listed below based upon-

- Visual Evaluation
- Signal-to-Noise
- the response and the Slope's SD

e. **Quantitation Limit (LOQ):** The analytical method quantitation limit is the least analyte present in a test sample may be precisely quantified by accuracy and accuracy as the exact amount. In quantitative tests, the quantitation limit is a parameter to determine contaminants and/or degradation products in sample matrices with low amount of chemicals. The determination of the quantitation limit depends on whether the process is non-instrumental or instrumental. Other strategies may be allowed in addition to those that are listed below based upon-

- The Visual Evaluation
- Signal-to-Noise Approach
- The Response of SD and Slope

The quantitation limit (QL) shall be expressed as: QL=10/S

Where σ is the SD of response, S being the slope of the calibration graph. The slope S shall be estimated from the analyte's calibration curve.

f. **Linearity:** Linearity is the analytical technique's ability to produce results equivalent to the standard solution concentration of the analyte.

g. **Range:** It's the range of analyte concentrations between the sample's upper and lower limits. The test sample should contain between 80 and 120 percent of the required range for testing of the assay.

h. **Ruggedness:** It is defined as reproducibility measurement in a range of situations, such as various laboratories, analysts, machinery, ambient conditions, operators, and so on.

i. **Robustness:** The robustness of an analytical technique demonstrates its dependability in routine usage by demonstrating its ability to stay unaffected by small but purposeful changes in process parameters. During the development phase, a robustness

assessment should be conducted, and it depends upon the technique being investigated. It should be able to show that the analysis is reliable even when the technique parameters are deliberately changed.

j. System Suitability Testing: Regarded as an essential component of the majority of analytical processes. The evaluations are founded on the basic idea that the instruments, gadgets, analytical procedures, and samples that are to be examined include an essential system that will be examined as such. The system suitability test variables for a chosen method are determined by the type of operation being verified. [16-28]

Cleaning Validation

The validation of cleaning guarantees that residues from factory facilities are successfully removed below a predefined threshold by the cleaning method. Cleaning validation is mostly utilized for cleaning process equipment in the pharma industry. Cleaning validation examines cleaning methods or cycles analytically. It should also describe that how acceptability criteria, such as chemical and microbiological parameters, detection limits, and sampling technique selection, were created.

Objective of Cleaning Validation

Cleaning validation makes sure that the used cleaning technique is effective in removing chemical leftovers, volatile compounds, conservants, additives, and/or cleaning solutions, along with the microbiological contaminants completely within a defined prescribed level. Furthermore, one must make sure that there should be no chance of active ingredients being cross contaminated.

Cleaning process should be validated for the following reasons:

- Other pharmaceutical products, cleaning agents, and microbiological contamination can contaminate pharmaceutical products and API.
- It is a necessary regulatory need for pharmaceutical manufacturing; and it is equally important – for the equipment to be all clean and that the quality product and safety are well met.
- It even assures manufacturing quality from the point of view of compliance and internal control activities.

Other Objectives

- Reduction of solvents
- Increased cleaning equipment and shorter cleaning times
- Equipment utilization, equipment life extension, and multiproduct
- Infrastructure, worker safety, and cost-effectiveness are few other objectives.
- The major goal of cleaning validation is to verify whether the technique involved in cleaning could reliably eliminate debris from the accessible product while staying within the Tolerances.

When Cleaning Validation is needed

- It is the 1st step /equipment qualification.
- A significant modification to a cleaning method.
- A significant modification in the formulation.
- There has been a significant modification in the formulation.
- A shift in the cleaning procedure.
- Substitution of the cleaning agent

Benefits of Cleaning Validation

- **Operator safety:** Validation can improve operator safety. Instruments and gauges that are properly calibrated and certified are used to decrease accidents and increase safety.
- **Better Customer quality:** Proper validation aids to reduce market recalls, result in improved customer service and quality of the product.

Mechanism of Contamination

- Cross-contamination of the active ingredients.
- Contamination due microbes.
- Contamination caused from cleaning the products or by or sanitizing them.
- Contamination caused by undefined additional materials.

Sampling Techniques

The study's objective of proving that the percentage of residue has been brought down to desired acceptable levels in the equipment that must be supported by choosing one of these approaches, which must be based on strong scientific reason. There are three types of sampling procedures that are widely used:

- **Direct Surface Sampling**
  It entails assessing the types of sampling techniques used and their effects on test results in order to determine whether the sampling material interferes with the test. As a result, it's important to check early on in the validation process that the sample medium and the solvents are suitable and simple to use. Direct sampling has the advantage of allowing you to sample the areas that are the most difficult to clean and that are the most cost-effective.
- **Swab Sampling**
  Careful site selection is necessary, because swabbing (direct surface sampling) does not encompass the whole surface area of the instrument. At the absolute least, the sample sites should indicate the equipment's worst-case locations, with the result being extended to take into account for the entire surface area under contact. Swabbing solvents should have excellent chemical solubility and should not induce deterioration.

Benefits of Swab Sampling:

1. The capacity to adapt to a wide range of surfaces.
2. Cost-effective and widely available
3. Active, microbiological, and cleaning agent residues are all

applicable.

- **Rinse Sampling**

  The most frequent approach for evaluating cleanliness is to rinse samples for residual active component. This is a pretty easy approach in many situations, although it does need a control over the rinse solvent, the length for time of contact, and the blending required. The solution that is used must be dependent on the API's solubility and should therefore mimic the latter batch of the pharmaceutical product or at the very least should offer acceptable dissolution. [29-31]

Equipment Validation

Qualification is the term used to describe the process of validating equipment. There are four types of equipment validation mentioned below (The IQ,DQ,PQ,OQ).An IQ records specified static characteristics of the premises or product to explain that the device is being properly placed and the is installed as per the manufacturer's guidelines. After installation, the equipment must be able to provide the operating limits indicated in the purchase agreement. OQ is the term for this. The purpose of the PQs is to show that the approach under study works as planned.

1. **Design Qualification (DQ)**

   There must be documented confirmation that the planned facility, system, and equipment design are well suited for the specified function. Here, the design's adherence to GMP should be shown. The design concepts for equipment should be such that they fulfill the GMP objectives. It is necessary to assess the mechanical drawings and design characteristics given by the equipment's manufacturer.

2. **Installation Qualification (IQ)**

   Food and drug management relies on process equipment and related systems to function consistently within certain restrictions and tolerances (FDA). It is mainly recorded whether the equipment, appliances that are installed or replaced comply with the manufacturer's specifications and guidelines. Installation qualifications for new or upgraded installations, systems and equipment should be carried out.

The installation qualification should comprise the following major points:

- Inspection of the setup of equipment's, pipelines, services and the devices.
- Collection of operating manual from the manufacturer and the needs for maintenance and calibration.
- Maintenance sources and replacement parts.

3. **Operational Qualification (OQ)**

   It is the recorded proof of the installed or updated facilities, systems, and equipment, will operate as planned within intended over the expected operational ranges. The OQ should have the following items:

- Tests based on a thorough understanding of the procedures, equipment and technology.
- Establishing low and high operational limitations. These situations are often known as very worst scenarios.

4. **Performance Qualification (PQ)**

   It offers a written recorded proof that once the instrument and auxiliary system is integrated, they will perform effectively and consistently according to the specified technique and required standard. PQ is the process of building trust in the effectiveness and reproducibility of a process as well as the process's compliance with design requirements. The equipment's performance qualification is a documented confirmation that it works as planned in your facilities. The essential characteristics of the equipment are examined utilizing appropriate test techniques during performance certification. Test specifications are used to document these procedures. Performance qualification, on the other hand, is required for all process equipment as well as crucial equipment. The decision to execute performance qualification or not is usually made on a case-by-case basis. [32-35]

Process Validation

Process Validation is "A written recorded proof, that offers a great level of confidence whether a particular mentioned process would continually create a genuine product," says Process Validation. The types of process validation are as mentioned below:

1. **Prospective validation**

   Establishing recorded proof that a system operates as intended based on a specified procedure is what it is characterized as. This certification is valid. Prospective validation is frequently done before new drugs and associated production processes are introduced. This technique of validation is generally utilized when a novel formula, procedure, or equipment is to be validated prior to commencement of any pharmaceutical product formulation.

2. **Retrospective validation**

   This type of process validation is the verification of the process for an already pre–existed product in the market on the basis of collected manufacturing, assessment, and control data in order to verify that the process has always stayed under command, is known as retrospective process validation. Older goods that were not initially confirmed by the fabricator when launched and at present need validation to meet the standards set out in Division 2, Part C of the Food and Drugs Act, might benefit from retrospective validation. Only well-established comprehensive processes are suitable for retrospective validation; it is not appropriate where product formulation,

operational procedures, equipment, or facility have recently changed.

3. **Concurrent Validation**
   Concurrent validation is said to be the combination of retrospective and prospective validation, and is performed according to a pre-approved technique, although the pharmaceutical commodity is distributed batch wise, and is typically utilized for an existing product that has not been validated or has been validated poorly. Concurrent validation is a way to demonstrate that an installation and its procedures are supported by the evidence gathered throughout the process real execution.
4. **Process Re-Validation**
   When modifications or variations in the process occur, revaluation of the process must be carried out, while where necessary, they can be revalidated. Revalidation can be classified into two categories:

- Revalidation after every modification that affects product quality, and
- Periodic revalidation at present intervals.

Revalidation after Changes

Revalidation shall be done on if there are any modifications and are affecting the standard manufacturing procedure that have an effect on the established product effectiveness attributes. The following are some common changes that necessitate revalidation:

- Alterations in the starting material(s)-Alterations in some physical properties of the active ingredients or excipients, such as density, viscosity of liquids , distribution of particle size, and crystal type and alteration, can modify the mechanical characteristics of the pharmaceutical ingredients and , in thus result, can have adverse effect the final product.
- Alterations made in the packaging material, Like- substituting plastic materials for material of glass might lead to modifications in the process of packaging that impact the stability of the product.
- Significant alterations made in the process For e.g. when the blending time is changed, temperature for drying is altered, along with cooling regime, this leads to have an impact on the quality of succeeding phases of the process along with the products.
- Alterations in the equipments, along with the measuring instruments- Repairs and maintenances can modify both processes and products, such as the substitution of major parts of equipment.
- Alterations in the manufacturing area along with the support system- For e.g. Changes in manufacturing process may result from the reorganization of production area and/or support networks.

Periodic revalidation

Even when experienced operators perform appropriately according to established methods, process changes might occur gradually. Wear and tear on equipment can also produce progressive changes. As a result, even if no modifications have been made intentionally, revalidation at set times are recommended.

Objectives of process validation

- The aim is to create a dependable manufacturing process, consistently producing a low variance pharmaceutical product that complies with pure, identical and power quality requirements.
- The manufacturing process, along with the individual equipment, must be validated.
- Following the first validation significant modifications will require re-validation with the equipment validation. Process validation produces a stable product, which over time would be highly reproducible.

Benefits of process validation

- Consistent in all aspects of production.
- A decrease in the number of rejections and reworks.
- Utility costs are reduced.
- Capital expenditures are minimized.
- Process-related failures receive fewer complaints.
- Testing and final goods are less expensive.
- Faster and more precise investigations of process deviations.
- New equipment starts up more faster and more reliably.
- It is simpler to build up from design process.
- Enhanced speed of automation.

Process Validation Pre-requisites

Manufacturing and control systems, along with the composition, must be qualified before validation of the process may begin. At the development stage, before submitting a marketing authorization application, the details concerning the drug product must be thoroughly examined and approved. Stability studies, as well as research on the interaction of active pharmaceutical ingredients and consumers, as well as the finished drug product and material of packaging, are all part of such a process. Validation of cleaning the equipments and facility cleanliness is required along with the other aspects of manufacturing, such as key utilities like water, the electric supply, etc. Personnel training along with proper encouragement are critical for successful validation. [37-40]

Major validation phases

There are 3 types of Validation study activities:

Phase 1: Pre-validation Qualification Phase-

This stage is also known as the process configuration stage, and it focuses only on capability initiatives. This phasing includes primarily all R&D activities including pilot group considerations,

scale-up studies, innovation transfer to small business scale clusters, the establishment of strength and capacity conditions, and the processing of in-process and completed measurement forms as well as gear capacity, setting capacity, operating capacity and process limitations. Additionally, using collected learning and comprehension of the procedure, the foundation of a plan for procedure control is formed at this phase.

Phase 2: The Process qualification-

During this process configuration stage, the procedure defined, is analyzed in order determine, is it the process efficient of reproducing business production. It certifies that each of the set-up points for basic process parameters are accurate, and the appealing objects can be delivered.

Process qualification has two components-

- Design of facilities and qualification equipment and utilities- Activities are carried out to ensure that the facilities are designed appropriately, and that the equipment and utilities are well suitable and functional.
- Process Performance Qualification- It includes creating performance objectives as well as selecting what to gather when, how much data to collect, and how to analyze the data appropriately. Manufacturers must establish and justify appropriate criteria based on scientific evidence.[41-45]

Phase 3: Validation Maintenance Phase-

This is often referred to as continued process verification. A frequent examination of all documents related to process, along with validating the audit reports, is needed to ensure that no manufacturing process alterations, variations, malfunctions occur. All operating procedures were implemented, especially change control processes. The validation team, which includes members from all key departments, verifies that no modifications or deviations have happened that would need requalification or revalidation during this phase. A great level of assurance may be established that all the lots of batches manufactured shall satisfy their desired criteria through means of careful designing and validating the systems. Operations are required to be performed according to the principles of good manufacturing practice (GMP) generally and in particular with regard to the production of sterile goods. [46-47]

VALIDATION REPORT

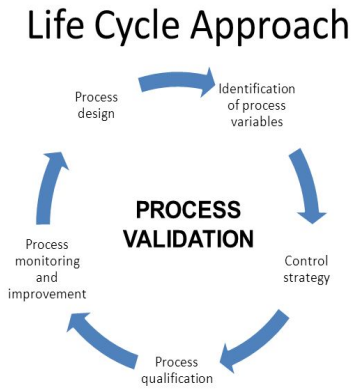
After the validation is completed, a written report should be provided. It should be approved and permitted if it is deemed to be acceptable (signed and dated). A validation report will be generated after the performance of the batches to verify procedure adherence. The actual output achieved at different stages must be compared to the formulation sequence of the validation batch processing documents.

At the very least, the validation report shall comprise of the following:

- Objectives with the title of the research being carried out shall be included.
- Protocol referral.
- Material details.
- Equipment used
- Used applications and processes
- Details about processes and testing procedures.
- Outcomes (In comparison with acceptance criteria).
- Suggestions on future restrictions and requirements.

VALIDATION LIFE CYCLE

Validation is a process that changes constantly. The validation process is a theoretical and rigorous evaluation of the workings of the system and processes ranging from most crucial to most extensive. Its scope includes the control, training, and system and process maintenance of documentation revision. Validation evidence should be visible throughout the company and represented in the management structure. Validation is an approach leading to building and maintaining high quality.



VALIDATION MASTER PLAN

It is an exhaustive document which gathers the complete information, purpose, and strategy of the organization to demonstrate its performance. Validation means that the different phases involved in the process must be well planned and prepared. In addition, all task should be assigned to the officially authorized standard operating procedure in a highly structured way. All the results should be noted and reported as real numerical findings whenever feasible. The entire validation process, including the regulatory system, its content and the planning is laid down in the VMP, content, and strategy. The master plan shall include all validation actions pertaining to significant scientific actions, and controls of products and processes inside the company. All prospective validations, contemporary validations, retrospective validations and re-validations should be

included. The master validation plan should be a short, brief and easy to comprehend summarizing document. It must be based on existing documentation such as policy documents, SOPs, validation methodologies, and reports, rather than repeats information that is already documented. [48-50]

CONCLUSION

The current literature study says that the most essential and recognized requirement for cGMP is pharmaceutical validation. Validation usually involves the compilation of documents related to a procedure, an item or equipment or an installation. The process validation is aimed at helping producers understand the needs of their quality management system (QMS) for process validation, and it may be applied to any manufacturing process. The product shall really be durable in order to endure manufacturing process fluctuations as well as competent and consistent just to assure its continuing safe function. Process validation follows a sequence of activities that occur throughout the product and process lifespan. Revalidation is indeed an essential concept for the validation process. Overall, the validation's goal is to prove that procedures associated in the research and fabrication of medicine, such as procurement, cleanliness, and analytical assessment, are reliable.

REFERENCES

1. Ahir KB, Singh KD, Yadav SP, Patel HS, Poyahari CB, 2014. Overview of validation and basic concepts of process validation, Sch, Acad J Pharm (2):178.
2. Alam SM, 2012. Pharmaceutical process validation: an overview, Journal of Advanced Pharmacy Education & Research, 2(4): 185-200.
3. Kaur H, Singh G, Seth N, 2013. Pharmaceutical process validation: a review, Journal of Drug Delivery and Therapeutics 3(4):189-94.
4. Jain K, Agarwal P, Bharkatya M, 2018. A review on pharmaceutical validation and its implications, International Journal of Pharmacy and Biological Sciences ISSN 2321-3272.
5. Wazade MB, Walde SR, Ittadwar AM, 2012. An Overview of Pharmaceutical Process Validation and Process Control Variables of Tablets Manufacturing Processes In Industry, International Journal of Pharmaceutical Sciences and Research 3(9):3007.
6. Swarbrick J, 2003. Pharmaceutical process validation, Nash RA, Wachter AH, editors, New York: Marcel Dekker.
7. Ghagare PM, Patil AR, Deshmane BJ, Kondawar MS, 2020. Review on Pharmaceutical Validation, Research Journal of Pharmaceutical Dosage Forms and Technology 12(1):17-26.
8. Thaduvai R, Rao BS, Jeybaskaran M, 2012. Process Validation of Pantoprazole 40mg Tablets, the Pharma Innovation 1(5, Part A):47.
9. Chavan AM, 2020. A review on pharmaceutical validation and its implications, Asian Journal of Pharmaceutical Analysis and Medicinal Chemistry 105-110.
10. Paruchuri R, Trivedi S, Pavuluri G, Prasanthi B, Kumar S, 2012. Process validation of finasteride tablets, International journal of pharmaceutical, chemical and biological sciences 2(1):11-28.
11. Sindhurnag N, Gouthami B, Madhuri L, Reddy LV, Krishnaveni N, Meyyanathan SN, Suresh B, 2012. The concept of process validation in tablet manufacturing: review, Journal of Pharmacy Research, 5(2): 1264-1267.
12. Nikam UA, Jadhav AV, Salunkhe VR, Magdum CS, 2013. An overview of pharmaceutical process validation of solid dosage form, Current Pharma Research, Vol 3(2): 824-835.
13. Nandhakumar L, Dharmamoorthy G, Rameshkumar S, Chandrasekaran S, 2011. An overview of pharmaceutical validation: Quality assurance view point, IJRPC1 (4):1003-14.
14. Edwards CM, 1989. Validation of solid dosage forms the FDA view, Drug Development and Industrial Pharmacy 15(6-7):1119-33.
15. Guideline on General Principles of Process Validation. Washington DC: Center for Drug Evaluation and Research, US Food and Drug Administration, 1987.
16. Sharma S, Khurana G, Gupta R, 2013. A Review on Pharmaceutical Validation and Its Implication, Indian Journal of Pharmaceutical and Biological Research 1(03):100-4.
17. Center for drug, Drug Evaluation and research, center for Biologics, Evaluation and Research, and center for devices and Radiological health food and Drug Administration, 1987. Guideline on general principles of process validation, pp 1-14.
18. Srivastava RK, Kumar SS, 2017. An updated review: analytical method validation, European journal of pharmaceutical and medical research 4(9):774-84.
19. Nayudu ST, Suresh PV, 2017. Bio-analytical method validation–a review, International Journal of Pharmaceutical Chemistry Research 3:283-93.
20. Lavanya G, Sunil M, Eswarudu MM, Eswaraiah MC, Harisudha K, Spandana BN, 2013. Analytical method validation: An updated review. International Journal of Pharmaceutical Sciences and Research.4 (4):1280.
21. Pasbola K, Chaudhary M, 2017. Updated review on analytical method development and validation by HPLC, World Journal of Pharmacy and Pharmaceutical Sciences 6:1612-30.
22. Ravichandran V, Shalini S, Sundram KM, Harish R, 2010. Validation of analytical methods–strategies & importance, International Journal of Pharmacy and Pharmaceutical Sciences (3):18-22.
23. Shweta K, Anita S, 2016. A review on analytical method validation, Int J Pharm Res Rev 30-36.
24. Boque R, Maroto A, Riu J, Rius FX, 2002. Validation of analytical methods, grasas Aceites 53,128-143.
25. Geetha G, Raju KN, Kumar BV, Raja, 2012. Analytical method validation: an updated review, Int J Pharm Biol Sci 1, 64-71.
26. Tijare LK, Rangari NT, Mahajan UN, 2016. A review on bioanalytical method development and validation, Asian J Pharm Clin Res 9,6-10
27. Daksh S, goyal A, Pandiya CK, 2015. Validation of analytical methods–strategy and significance, Int J Res Dev Pharm Life Sci 4, 1489-1497.
28. Araujo P, 2009. Key aspects of analytical method validation and linearity evaluation, J Chromatogr B 877, 2224-34.
29. Active Pharmaceutical Ingredients Committee 1999. Cleaning validation in active pharmaceutical ingredient manufacturing plants, Active Pharmaceutical Ingredients Committee.
30. Murthy DN, Chitra K, 2013. A Review Article on cleaning validation, International journal of pharmaceutical sciences and research 4(9), 3317.

31. Robert Fredrick, 2004.The Basic Facts of Cleaning Validation, Canada.
32. Zameeruddin M, Kale SS, Jadhav SB, Kadam VS, Chaware SS, 2015. Process validation of oral solid dosage form: tablet–an overview, World Journal of Pharmacy and Pharmaceutical Sciences 4(12), 358-73.
33. Kakad SB, Kolhe MH, Dukre TP, 2020. A Review on Pharmaceutical Validation, International Journal of Pharmaceutical Quality Assurance 11(03):338-42.
34. Kashid VA, Nikam VK, Somwanshi SB, Dolas RT, Dhamak KB, Gaware VM, Kotade KB, 2014. Brief overview of pharmaceutical facility validation, Journal of Current Pharma Research 4(2), 1134.
35. Kashid VA, Nikam VK, Somwanshi SB, Dolas RT, Dhamak KB, Gaware VM, Kotade KB, 2014. Brief overview of pharmaceutical facility validation, Journal of Current Pharma Research 4(2), 1134-1137.
36. Padigapati AR, 2012. Saurabhsharma pharmaceutical process validation: An overview, Global Journal of Pharmaceutical Research, 1(4), 766-84.
37. Dukandar AD, Tandel FB, Jha LL, Prajapati MP, 2015. Process Validation of Ibuprofen Film Coated Tablets, International Journal for Pharmaceutical Research Scholars 4(2), 169-188.
38. Wawre M, Dodke B, Moon A, Javalkar G, 2017. Industrial process validation in solid dosage form: a review, World Journal of Pharmacy and Pharmaceutical Sciences 6(3), 301-316.
39. Reddy MS, Chandramouli R, 2017. Functional overview of process validation of tablets - a critical review, Journal of Pharmaceutical Research 16(3), 268-277.
40. Sharma V, Seth N, 2014. Industrial process validation of tablet dosage forms: A review. International Journal of Pharmacy Review & Research 4(2), 80-4.
41. Oechslein C, Lazar M S, 2012. Process Validation from view report of the FDA, Maas and Peither AG –GMP Publishing, logfileno.
42. Harisudha K, Lavanya G, Eswarudu MM, Sunil M, 2013. An overview on pharmaceutical process validation, International Research Journal of Pharmaceutical and Applied Sciences 3(1), 165-8.
43. Ojha A, Bharkatiya M, Santosh K, 2014. Pharmaceutical process validation of solid dosage forms: a review, World Journal of Pharmacy and Pharmaceutical Sciences 3(6), 476-484.
44. Ira R Berry, Robert A Nash, “Pharmaceutical process validation”,second edition, pp 168-280.
45. Sharma M, Agarwal S, Agarwal S, Sharma M, 2015. Prospective validation: a review, The Pharma Innovation.
46. Good Manufacturing Practices for Pharmaceutical Products. WHO Expert Committee on Specifications for Pharmaceutical Preparations, 32nd Report, WHO Technical Report Series no 823, Geneva: WHO, 1992: pp 14-96.
47. South African Guide to Good Manufacturing Practice, Pretoria: Medicines Control Council, 1996.
48. Sharma A, Saini S, 2013. Process validation in pharmaceutical industry: A Review, Pharma science monitor.
49. Paruchuri R, Trivedi S, Pavuluri G, Prasanthi B, Kumar SM, 2012.Process validation of finasteride tablets. International Journal of Pharmaceutical, Chemical and Biological Sciences, 2(1), 11-28.

How to cite this article

Alka N Choudharya, Tanya Sehgal, 2021. A review on pharmaceutical validation and its implications. Jour. of Med. P’ceutical & Allied. Sci. V 10 - I 6, 1927, P- 3951-3959. doi: 10.22270/ jmpas.2021.V10I6.1927