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A Review on Qualification of Analytical Instrument (With Case Study)

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ABSTRACT
For the pharmaceutical industry, accurate performance of analysis devices will be important as reliable data must be ensured in the hands of companies during every development and manufacturing stage together with quality control. Therefore, calibration and qualification are also important and find a place in GMP standards. The community of users, manufacturers, and quality assurance professionals accepts analytical instrument qualification as the norm. Therefore, performance qualification is only important in proving critical equipment parameters that are required in terms of standards to be achieved. Performance qualification includes a thorough audit of the main characteristics of the equipment. Qualification does not only include checking about the correct installation and operation but also continuous evaluation and cyclical requalification of the instrumentation. A crucial relationship in qualification is associated with quality data ideas, including method validation, system appropriateness, and quality control at every stage.

KEYWORDS: Components of Data Quality,Design Qualification**,** Installation Qualification,Operational Qualification, Performance Qualification.

I. INTRODUCTION

Calibration and qualification of equipment are key requirements in GMPguidelines [1].The pharmaceutical industry relies on the precision and accuracy of analytical instruments to obtain valid data for research, development, manufacturing, and quality control. Indeed, advancements in the automation, precision, and accuracy of these instruments parallel those of the industry itself[2].

Generally, the fitness of systems for the intended purpose (i.e., their quality) needs to be ensured through constructive and analytical measures. Constructive measures are defined in terms of recognized professional engineering practices and include formal design methodologies that typically follow a life-cycle approach. System qualification follows a structured approach that uses test cases and test parameters based on a scientific and risk-based analysis. Defining and executing these tests typically require the use of metrology[3].

Analytical Instrument Qualification is the collection of documented evidence that an instrument performs suitably for its intended purpose. Use of a qualified instrument in analyses contributes to confidence in the validity of generated data[4].

COMPONENTS OF DATA QUALITY[5,6,7]

There are four critical components involved in the generation of reliable and consistent data (quality data). Figure shows these components as layered activities within a quality triangle. Each layer adds to the overall quality. Analytical instrument qualification forms the base for generating quality data. The other components essential for generating quality data method validation, system suitability tes quality low.

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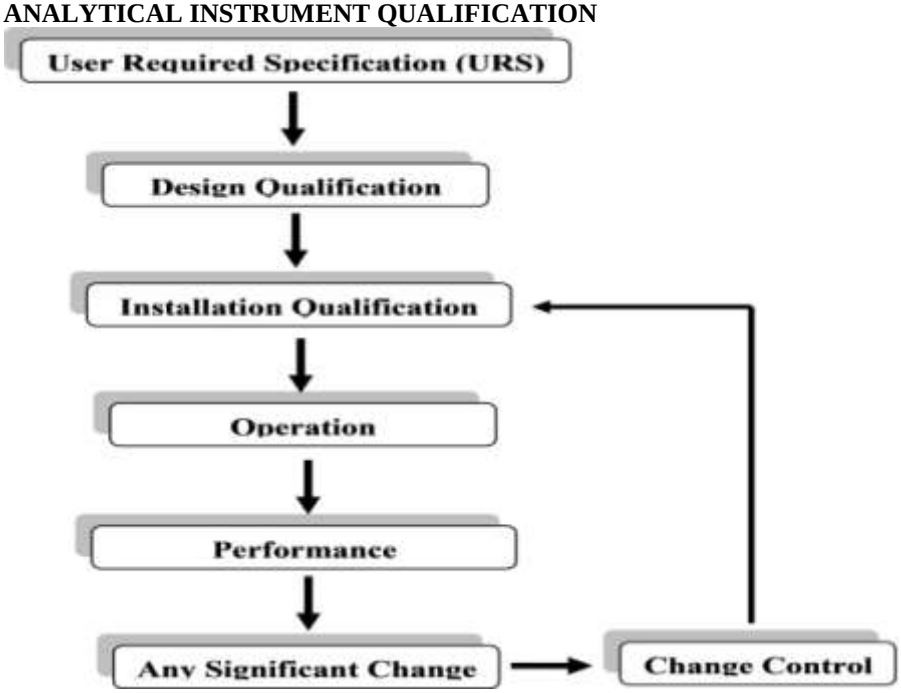
Qualification is documented evidence that premises, systems or equipment are able to achieve the predetermined specifications when properly installed, and/or work correctly and lead to the expected results[8].It is the programmed operation as per feeding instructions of the instrument[9].It is the proof that new equipment is fit for its intended purpose. This is achieved by fully defining all of the required characteristics of the measuring system and then proving that the selected equipment meets the requirements before using it for analysis. Reduced likelihood of incorrect test results as the equipment's performance has been proved to be suitable for its intended purpose both before it is used for test sample analysis and during its working life[10].

Qualification is part of validation, but the individual qualification steps alone do not constitute process validation. It is the entire process by which products are obtained from manufacturers or distributors, examined and tested, and then identified as a qualified products list. In general, qualification and validation follow similar underlying principles. The term "qualification" is normally used, for example, for equipment and utilities, and "validation", for example, for systems, methods and processes. Qualification normally precedes validation[11].

STAGES OF ANALYTICAL INSTRUMENT QUALIFICATION



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Instrument qualification is not a single continuous process, but instead results from several discrete activities. For convenience, these activities can be grouped into four phases: Design qualification (DQ), Installation qualification (IQ), operational qualification (OQ), and performance qualification (PQ)[12].Qualification activities should consider all stages from initial development of the user requirements specification through to the end of use of the equipment, facility, utility or system. The main stages and some suggested criteria (although this depends on individual project circumstances and may be different) which could be included in each stage[13].Analytical Instrument Qualification (AIQ) is accepted widely within the community of users, manufacturers and quality assurance across industries and manufacturers. Manufacturing process validation also has these qualification phases originating at different stages of its orientation[14,15,16]. Thus, it is very crucial that the required AIQ activities are in place. Some AIQ activities may be carried out in one or the other qualification process and it is not mandatory for these individual activities to be captured under single qualification head, can be performed and reported under different subgroups under which the individual activity is performed or reported[17,18,19].

DESIGN QUALIFICATION (DQ)

To verify that a proposed design meets the intended purpose, we are required to understand each of these terms. The challenge is that both the definition of the "purpose" and "design" evolve during the life of a project. So there is a temporal component to DQ that must be addressed. The pharmaceutical manufacturer should decide early in the project when a DQ will be executed[21].The Design Qualification activity is most suitably performed by the instrument developer/manufacturer. Since the instrument design is already in place for the commercial off-theshelf (COTS) systems, the user does not need to repeat all aspects of DQ[22]. DQ is aimed to verify that the system / instrument has been designed suitably for the intended purpose. In particular:
– the design meets the user requirement specification (URS);
– the design complies with all the applicable guidelines and standards
– the design complies with the validation master plan (VMP)[23]

Design Qualification (DQ) is the process of documenting all aspects of a specific equipment design, from selecting qualified suppliers to meeting the final system requirements by comparing specifications with user needs[24]. Design Qualification is concerned with what the instrument is required to do and links directly to fitness for purpose. DQ provides an opportunity for the user to demonstrate that the instrument's fitness for purpose has been considered at an early stage and built into the procurement process[25].In this phase tests are done to assure that product meets all defined requirements under all anticipated conditions of manufacturing, i.e. worst case testing[26].

DQ Proposal are[27]

- Description of that purpose and intended use of the equipment.
- Descriptions of that proposed environment.
- Description for usage of that equipments into the designated atmospheres / process.
- Primary selectivity of that function as well as performance specification (high-technical,surroundings, protection, security access, compatibility with existing / future systems.
- Consultation and documents of contract, accommodation, trainings and supplementary supplier (vendor) facilities.
- Verification for Material of Construction (MOC).

INSTALLATION QUALIFICATION (IQ)

Establishes that the instrument is delivered as designed and specified, that it is properly installed in the selected environment, and that this environment is suitable for the operation and use of the instrument[28] . It evaluates means of accomodating new equipment and testing its materials. Systems and equipments should be correctly installed in accordance with an installation plan and installation qualification protocol. Installation qualification should include identification and verification of all system elements, parts, services and controls. There should be documented records for the installation which should include the details of supplier and manufacturer, system or equipment name, model and serial number, date of installation, spare parts, relevant procedures and certificates. For installation qualification, we'll first look at the equipment material[29].

Documented verification that all key aspects of hardware installation adhere to appropriate codes and the computer system

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specification [30]. Establishing confidence that process equipment and ancillary systems are capable of consistently operating within established limits and tolerances[31]. Some common IQ requirements are listed below[32]

- All instruments in the instrument list are installed and correctly tagged.
- Instrument calibration records available.
- Verification that any material in contact with the product, ingredients and/or cleaning material meet the requirements (certificates for material of construction and finishes).
- Schematics available and the system is verified to be built accordingly.
- Reference documents (e.g. manuals, specifications, and vendor prints) available.
- Software documentation.
- Environmental criteria (e.g. temperature and humidity) available.

The purposes of IQ are[33]:

- System completion: Check that the system is mechanically complete and all critical punch list items have been cleared.
- Security / Utility Connections: Check that the correct connection of utilities has been made and tested where required.
- Documentation Inventory: Check that all necessary supporting documentation such as specifications, operation and maintenance manuals are available and have been reviewed and approved.
- Equipment Inventory: Check that installed equipment name plate data complies with specification and record serial numbers.
- Materials Qualification: Check that, where appropriate, contact part materials, surface finishes and lubricants are in accordance with the specification.
- Main equipment features: Check that each main component is in accordance with the construction drawing, check critical specifications such as filter grade, perform any static checks required prior to start up, such as checking lubricant levels, drive belt tension and torque settings.
- Instrument calibration: Check that all critical instruments have been calibrated ad that the calibration is traceable to national standards.
- Spares and maintenance: Check that adequate spares provision has been made and maintenance requirements have been considered.

Recommendations to installation qualification[34]

- The installation qualification protocol should has the description of the equipment/system to be qualified following carefully the manufacturer recommendations that show too the proper utilities connection, the confirmation that the construction material is proper, if the case of surface contacts the product.
- List of system instrument, when applicable: list the instrument as critic or no critic. The critics are those whose operation affects the system operation or quality attributes. The no critics are those provided only for information purpose and label as "no require calibration". Include as applicable: number traceable, manufacturer, location and description for each instrument.
- All installed critic instruments (accuracy and precision as process tolerance) in the equipment or system to be qualified previously should be calibrated with their respective calibration certification, properly filed and current.
- The equipment and systems should have their respective controls, a list of parts and spare components if necessary and applicable, as critical analysis in the involved area with the maintenance.
- The user requirements (UR) should be verified.
- All physic details of installation and services should be in conformity and obeying with the use purpose.
- The dimensional drawings, technical specifications and operating manuals have the purpose to document the installation and placement of each component always should be available and updated in the moment of installation qualification.
- Lubricants used, if necessary, should attend the manufacturer specifications and not adversely affect the quality of the product.
- Report qualification deviations (is necessary to open report non-compliance (RNC) in treatment of non-compliance and continuous improvement (TNCMC): document any discrepancy or variation observed during execution of the installation qualification. Include the resolution of the discrepancy and/or any detachable point that requires more effort for resolution. When all items were satisfactorily resolved or if exist an action plan developed and approved that ensure they were resolved, document that the system is ready for operation qualification.
- The GMP should follow with accuracy, so that, the involved in the qualification were properly trained within the defined concepts for this work.

Visual inspection :This is our first view of the equipment as installed. The intent is to verify that

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the correct machine is installed, that installation matches design, that installation matches equipment manufacturer's recommendation and that the installation is complete. Details vary widely depending on the equipment[35].

Failures in an Installation Qualification are rare but do happen. They will generally be misconnected utilities or the like. All Exceptions must be corrected prior to submittal of the protocol for final approval[36]. On obtaining acceptable results, the user and (when present) the installing engineer should confirm that the installation was successful before proceeding with the next qualification phase[37].

OPERATIONAL QUALIFICATION (OQ)

Operational qualification should provide documented evidence that utilities, systems or equipment and all its components operate in accordance with operational specifications. Tests should be designed to demonstrate operation over the normal operating range as well as at the limits of its operating conditions (e.g. including worst case conditions)[38].In the OQ phase of process validation, the process input parameters should be challenged to ensure that they will result in a product that meets defined requirements under all anticipated conditions of manufacturing, i.e. worst case testing. The use of statistically valid techniques, such as screening experiments to establish key[39].

OQ considerations list[40]

- Process control limits (input variables)
- Software parameters
- Raw material specifications
- Process operating procedures
- Material handling requirements
- Process change control
- Training
- Short term stability and capability of the process
- Potential failure modes (Failure Mode and Effects Analysis, Fault Tree Analysis)

Recommendations to operation qualification[41]

- The operation specification of the manufacturer should be available and detailed. - Be in conformity with the operational procedures of cleaning and maintenance of each equipment.

- Should be available in the content of the operation qualification protocol, the operational tests of the system, operation challenges, check alarms and demonstration of effectiveness of each operate component (all instrument, switches and alarms of the equipment will checked for functionally together with operational qualification).

- List of the required instruments for operational qualification should previously be calibrated with their respective calibration certification, properly filed and current.

- Report qualification deviations (is necessary to open RNC in TNCMC): document any discrepancy or variation observed during execution of the operation qualification. Include the resolution of the discrepancy and/or anydetachable point that requires more effort for resolution. When all items were satisfactorily resolved or if exist an action plan developed and approved that ensure they were resolved, document that the system is ready for performance qualification

Acceptance criteria for operation qualification[42]

- All relevant document of operation qualification (monitoring and functional test of the system) should be completed and approved. The operational qualification will document that the equipment is able to operate within specified parameters.

- All use points should be installed and available for normal operation use.

- All recommendations for operation qualification should have been performed.

- The records and reports should coincide with specific data.

Operational Qualification ought to be directed in three phases[43]:

- Component Operational Qualification, of which adjustment can be viewed as a large part.
- System Operational Qualification to decide whether the whole framework works as a coordinated entirety.
- Process Performance Qualification: This checks the framework is repeatable and is reliably creating a quality item.

The tests involved in the OQ are as follows[46]:

-Calibration verification for critical instruments: Critical instruments are those that give data that is documented in maintenance or production records. It is necessary to confirm that they are currently calibrated. Included are vital instruments such as pressure gauges and pressure sensors, temperature sensors, flow meters, flow meters, RH display systems, and data recorders/loggers.

-Compliance test for operational procedures: It is important to confirm that there is a final draft or more advanced SOP available for the working of the HVAC system's instrument and individuals in charge of the system or any of its parts during OQ.

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It is necessary to confirm that execution has been trained in accordance with the mentioned SOP. The operational procedure ensures that running the system does not affect the results of any one of the separate OQ tests.

-Variation in pressure: The test's objectives are to confirm the HVAC system's functionality and sustain the designated pressure differential between the spaces among the several rooms that make up the installation as well as the surrounding areas. The manometer that is fastened to the walls of the nearby region is used to measure the pressure differential. Generally, the pressure differential is maintained between 5 mm/hg and 20 mm/hg [6].

-Acceptance criteria: >10 Pa separates the classified area from the lower concentration area next to it and >15 Pa separates the classified area from the unclassified area.

-HVAC operation test for startup and shutdown: The AHU's sequence is managed by the controlled system.The device that intervenes in the system and the procedure to be followed should both be specified in theprotocol[44].

-The loss of utility test: In every situation, the response to a power outage needs to be evaluated. Thisincludes testing the equipment/system response and the retention of important data. Equipment mustbehave in line with the documentation that is currently accessible when a particular utility is lost orresumed. Compressed air, clean steam, electricity, hot and cold water, chilled water, and glycol are examplesof support utilities for HVAC systems.

-Testing for filter integrity (DOP/PAO test): HEPA filters undergo the filter integrity test, which is carried outby utilizing an aerosol generator to create a PAO aerosol and permitting the aerosol to ascend. The amountof reversed aerosol is determined by monitoring the HEPA's receptor probe. The total amount of redirectedaerosol must not go over the HEPA filter's upper limit. This test used to be performed using DOP; however,due to DOP's carcinogenicity, it is no longer permitted and is now conducted using PAO instead of DOP[45].

Acceptance criteria: The rate of leakage in all the terminal HEPA filters should be NMT 0.01%.

Installation qualification protocol

The IQ protocol should include a statement of the data required and acceptance criteria to be met for installation of the system or equipment to verify that the specification has been satisfied.The protocol should include as applicable, but not be limited to:

- Engineering drawing and documents
- Building finishes
- Process and utilities (services) flow diagrams
- Piping and instrumentation diagrams
- Equipment and instrument specifications
- Manufacturers' drawing, equipment maintenance, and operating manuals
- Spare lists
- Maintenance schedules

The IQ protocol should also ensure that equipment and instrumentation is clearly described and suitably labeled as to vendor, model, capacity, materials, and other critical criteria. The IQ protocol should ensure that instrumentation has been calibrated according to approved procedures and that the measurements are traceable to defined national or international standards. All such calibrations and detailed control parameters must be recorded and records securely kept.

It should also ensure that change control systems are in operation, and that all systems have been verified to operate under no load conditions.

PERFORMANCE QUALIFICATION (PQ)

Performance qualification should provide documented evidence that utilities, systems or equipment and all its components can consistently perform in accordance with its specifications under routine use. Test results should be collected over a period of time to prove consistency[47].PQ should be performed for Minimum and Maximum occupancy capacities of pan with standard baffles as well as reduced baffles[48].The ability of a system, utility or piece of equipment, and each of its parts to regularly function in compliance with the specifications. According to PQ, the documentation ought to be used to facilitate regular usage. Test results must be obtained over a suitable period of time in order to show consistency[49].

PQ Proposal are[50]:

- Authentic products, all parameter of process and procedures are recognized into the PQ. All test, via formulating raw-materials, eligible alternatives otherwise simulated products proved that having comparable performance beneath standard operational condition as in worst-case batch proportions. The confirmed process must be justify via frequency of sampling methods.
- All the tests must be covered in that operative tentative limit for that proposed process, if documentary confirmation of that development

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stages assuring to the operating ranges are obtainable.
- Repeatable process, long- term process stability.

It consists of[51]:
 Perform actual functioning tests with the product (or placebo) and with the user personnel.
 Check the influence of the operating parameters on the load.
 Perform functional tests on the product at each critical stage of the process.
 Perform system performance measurements.
 Ensure the reproducibility of the performances obtained in load on several tests according to the specifications and specifications pre-established.

Documented evidence that the equipment operates in your facilities exactly as intended is called performance qualification. This is done by confirmingthat the equipment is appropriate for the work at hand and the actual operating circumstances of the environment. Performance qualification examines the equipment's important parameters using appropriate test techniques. Test specifications are used to document these procedures. However, performance qualification is to be performed for all the process equipment and the critical equipment[52].

PQ concern consists of[53]:
• True product, procedure parameters, and process set up in OQ.
• Adequacy of the product.
• Guarantee of technique ability as built up in OQ.
• Process repeatability, prolonged process stability.

PQ represents the final qualification of the instrument and is the most time consuming phase. The PQ is usually performed by the key operator and the lab personnel who will be primary users of the instruments.
a. In the event that a laboratory already has an existing validated IVD or LDT assay and plans to run that assay on a newly qualified instrument, a verification that the assay specifications can be reproduced on the new instrument will serve as the PQ
b. For IVD assays, where the manufacturer has already validated the assay and received clearance from regulatory bodies (such as FDA); a verification that the laboratory can reproduce those specifications in their lab, will serve as the PQ.
c. For new Laboratory Developed Tests (LDTs), the initial method validation serves as a comprehensive PQ. This will be covered in detail in a subsequent Q & S Module[54].

The essence of the problem is to assess the extent of the testing in detail, depending on the initiated change on the system. Efficient risk analysis should be carried out by an expert team that has sufficient knowledge about design and application of the system, and as such, a testing evaluation should be given, after which the system with high reliability will continuously deliver the expected results[55]. The PQ demonstrates that the manufacturing process can produce a consistent result using the nominal process setting every time the process is run. The idea is to demonstrate that the process can produce the same result consistently when considering the various sources of common-cause variation, such as manufacturing shut-downs for maintenance, changeovers from one job to the next, raw material lot changes, etc[56].

Requirements of PQ[57]-
- Set up test SOP
- Training of users
- SOP for operation, calibration and maintenance
- Routine performance test
- User requirement specification compliance
- Preventive maintenance and repair

It is not mandatory to perform Performance Qualification on all equipments or instruments. However, Performance Qualification is to be performed for all the process equipments and the equipment that are critical. The question on whether not to carry out Performance Qualification is generally done on a case-to case basis[58].At various stages in a validation exercise there are needs for protocols, documentation, procedures, specifications and acceptance criteria for test results. All these need to be reviewed, checked and authorized. It would be expected that representatives from the professional disciplines, e.g., engineering, research and development, manufacturing, quality control and quality assurance are actively involved in these undertakings with the final authorization given by a validation team or the quality assurance representative[59].

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PQ check items[60,61]

- Actual product and process parameters and procedures established in OQ.
- Acceptability of the product.
- Assurance of process capability as established in OQ.
- Process repeatability, long term process stability.

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-bycasebasis[62].

DOCUMENTATION

The written protocol is reviewed and agreed. It should importantly step and condition for acceptance. It contains notes, eligibility or validation protocol should be prepared, to obtained the summarize results, Discussion on any observed deviations and making the certain decision[63].Documentation should provide information necessary to verify qualification. Documented evidence of qualification of equipment should be available in an auditable form till the life of the plant. These records should be organized in an understandable and traceable manner. The records should be in a form allowing independent verification.Records demonstrating that EQ has been established, should contain information on the specific equipment being qualified, the demonstrated safety functions, applicable service conditions, test specifications, qualification methods, results, limitations, justifications and relevant supporting technical data[64].

Basics of Documentation[65]:

- Documents designed, prepared, reviewed and controlled, wherever applicable, shall comply with these rules.
- Documents shall be approved, signed and dated by appropriate and authorized persons.
- Documents shall specify the title, nature and purpose. They shall be laid out in an orderly fashion and be easy to check. Reproduced documents shall be clear and legible. Documents shall be regularly reviewed and kept up to date. Any alteration made in the entry of a document shall be signed and dated.
- The records shall be made or completed at the time of each operation in such a way that all significant activities concerning the manufacture of pharmaceutical products are traceable. Records and associated Standard Operating Procedures (SOP) shall be retained for at least one year after the expiry date of the finished product.
- Data may be recorded by electronic data processing systems or other reliable means, but Master Formulae and detailed operating procedures relating to the system in use shall also be available in a hard copy to facilitate checking of the accuracy of the records.

Documentation from supplier shall include[66]:

- Identification of the equipment;
- Identification of the functions important to safety;
- Identification of the installation of the equipment, including mounting, orientation, electrical and mechanical interfaces;
- Identification of the normal environmental conditions, the design basis events and the accidental conditions;
- Evaluation of the signification ageing mechanisms, of the methods to address them in the programme and the results of the age conditioning, if applicable;
- Identification of margin, if applicable;
- Identification of the qualified condition of the equipment;
- Presentation of the seismic result when applicable;
- Identification of the accident test results, including a description with graphics of the applied conditions;
- Identification of scheduled maintenance, periodic tests or components replacements to maintain qualification; and
- Summary and conclusions.

Documents from different stages of qualification are[67]:

- P&ID (as built)
- PFD
- Purchase order
- Current SOPS
- User requirements
- Design specifications
- LOGS

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- Equipment arrangement drawings
- Operational manual
- Cleaning manual
- Preventive maintenance manual

Qualification protocols[68]

There are various different approaches to the format and content of qualification protocols for example, protocols can be developed as stand-alone docu- ments or can cross-reference other project engineering documentation. They can be designed so that results are recorded within the body of the protocol or that all the detail is left for recording in the reports. The former results in bulky protocols but brief reports, whereas the latter results in slim protocols and bulky reports. As with all validation work the protocols should be developed in accordance with company policies and procedures. There should be SOPs for protocol preparation, execution and reporting.

Whatever approach is taken, there are certain key features that the protocolmust have. These can be summarized as follows:

- formal documents: The protocol must go through a review and approval process with final approval by QA; this must be numbered, the number of copies must be controlled and have a document revision history, page numbering must pass the 'drop test';
- defined scope: The protocol must define what area, equipment, etc., it addresses. This may be achieved by, for example, a system description, diagram or list of items; Pharmaceutical Production: An Engineering Guide edited by Bill Bennett, Graham Cole
- objective: The protocol should describe the purpose and how this relates to the overall validation activity and scope of the protocol;
- test structure: Each test must describe the objective and purpose of the test, qualification protocol Go the test procedure and the method of recording results. This should be in sufficient detail so that it could be understood by a third party, and repeated if necessary
- acceptance criteria: Each test must have acceptance criteria as to what constitutes a pass or a fail. The acceptance criteria must be approved before execution of the protocol.

ROLES ANDRESPONSIBILITY [69]

Users

Users are ultimately responsible for the instrument operations and data quality

Users group includes analysts, their supervisors, and the organizational management. Users should be adequately trained in the instrument's use, and their training records should be maintained as required by the regulations.

Quality Assurance

The quality assurance (QA) role in AIQ remains as it is in any other regulated study. QA personnel should understand the instrument qualification process, and they should learn the instrument's application by working with the users. Finally, they should review the AIQ process to determine whether it meets regulatory requirements and that the users attest to its scientific validity.

Qualification of equipment, systems and validation of methods, wherever applicable, are also important to generate accurate results[70].

CASE STUDY

QUALIFICATION OF CONE BLENDER[71]:

Cone blender Installation Qualification:

- Verify approved purchase order.
- Verify invoice.
- Check manufacturer and supplier.
- Verify model number and serial number.
- Check for any physical damage.
- Confirm location and installation requirements per recommendation of manufacturer.
- Verify that the required utilities are available.
- Installation shall be conducted per the instructions provided in the manual.
- Ensure that all relevant documentation is received:
- User manual
- Maintenance manual
- List of change parts
- Electrical drawings
- Mechanical drawings

Calibration of the control and recording equipment: Instruments for measuring temperature, pressure, time, mixing chamber slope, and mixing velocity, as well as recording devices for these variables, should be calibrated.

Operational Qualification[72]:

- Verify alarm control.
- Perform calibration requirements, identified in the manual or established by the validation team.
- Operate the equipment at low, medium, and high speed per operations manual to verify the operating control.

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- Verify that all switches and push buttons are functioning properly.
- Establish procedures for operation, maintenance, and calibration.
- Establish training program for relevant staff.

Net capacity of the mixing chamber:
Procedure-

Fill the mixing chamber with reweighed quantities of water. The available net capacity should be equal to the supplier specification. Mixing or stirring velocity: Measure velocity three times at low, medium, and high speed and compare the average and deviation from the average of the single measurements with the supplier specification. Requirements Compliance with the supplier specification
Performance Qualification[73]:

Product homogeneity:
Mixing process: Procedure:

Fix the mixing or stirring velocity, load the mixer with the product and switch the mixer on. After previously fixed intervals, the mixer should be switched off and samples should be taken from different locations of the product surface. The samples should be analyzed for their active content.

Unloading[74]:

Procedure: After determination of the suitable mixing time to achieve product homogeneity, the influence of the unloading process on the homogeneity should be evaluated. Samples should be taken and sent to QC for analysis. Requirements: Homogeneity should remain consistent. Water content of the product: Take samples of the product prior to mixing, after mixing, and after unloading (begin, mid, end). Determine the water content of all samples.

II. CONCULUSION

As such, analytical data in the pharmaceutical industry needs to be of high accuracy and reliability. Calibration and qualification of equipment would now be required for maintaining the integrity of such data, all within the stricture of the requirement of regulatory agencies under Good Manufacturing Practices (GMP). The proper Analytical Instrument Qualification process provides documented evidence that instruments are fit for their intended use in support of the confidence that data generated are valid.

The qualification process not only ensures the equipment is installed and operated correctly but also involves tests across its entire lifecycle to verify its performance. The formation of a blend of scientific and engineering practices, with metrology, minimizes the risk of giving erroneous results and generally increases the reliability of analytical processes.

All of this, with method validation and system suitability testing, leads to high quality, consistent data that support the credibility of processes in research, development, and manufacturing in the pharmaceutical industry and form the cornerstone for safe and effective products.

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