# Principles of Cleanroom Validation

## A cleanroom must be validated and certified to a particular class before operation.

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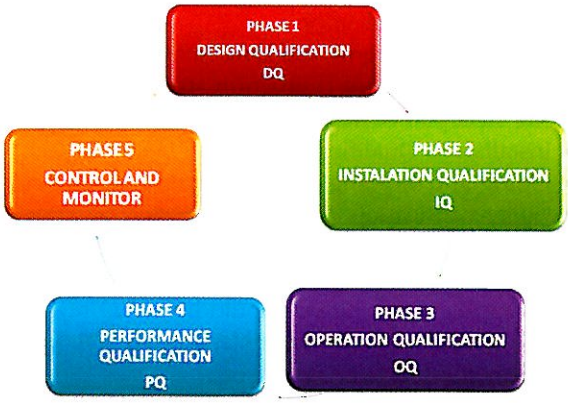


A cleanroom is a modular environment in which the following environmental factors are kept under control; temperature, airborne particulates, microbes, relative humidity, differential pressure, and air flow.

Cleanroom Validation is performed for a variety of reasons. To ensure that the design of the facility is fit for its intended purpose; to ensure that the facility, equipment, and environment meets User Requirement Specifications (URS); to ensure that the facility, equipment, and environment meet defined regulatory requirements; to ensure that the facility, equipment, and its environment function together as a system to meet defined standards.

Cleanrooms are validated and then certified to a chosen class of ISO 14644-1. Each class of ISO14544-1 has its unique requirements that must be made for a facility to be classified in the specified classification.

### CLEANROOM VALIDATION LIFE CYCLE

Validation of a new cleanroom follows a specified lifecycle. The life cycle comprises five phases each of which accomplishes particular tasks to control variation in the modular environment.

Cleanroom validation work is accomplished through five phases. It starts off with the design control phase and ends with monitor and control. Changes to equipment and control factors after the cleanroom has been validated are grounds for cleanroom re-validation.

### PHASE ONE: DESIGN QUALIFICATION

Cleanroom validation starts with Design Qualification (DQ). The purpose of this phase is to prove through objective evidence that the design is fit for its intended purpose. Design Qualification is a verification exercise against requirements defined in the acceptance criteria of your DQ protocol.

The protocol should address the following:

- User Requirement Specifications(URS)
- Vendor documents and specifications
- Facility layout
- Purchase orders
- Design documentation
- Factory Acceptance Tests(FATs)
- As build drawings
- Data sheets

The output of the Design Qualification phase is a phase report and an Standard Documentation List (SDL) file that documents the following:

1. Design requirements
2. Bidding requirements
3. Purchasing and order documentation
4. Vendor supplied documents list
5. As build drawings
6. Component lists
7. Inspection lists
8. Factory Acceptance Tests

The approval of the Design Qualification, DQ phase is a pre-requisite for the initiation of the Installation Qualification, IQ phase.

## PHASE TWO: INSTALLATION QUALIFICATION

The purpose of this Installation Qualification (IQ) phase is to confirm through verification that equipment—as installed—confirms to user requirements and design requirements. Verification is focused on the following items that should be called for in your IQ protocol:

- HVAC calibration
- P&ID loop verification
- HEPA filter integrity test data review
- Critical equipment calibration status
- Site Acceptance Tests(SATs)
- Installation Qualification tests
- Piping and welding documentation
- Utility verification
- System standard operating procedures and work instructions

The output of this phase should be an IQ report addressing all the above elements, and an SDL file that documents the following elements:

1. Project changes
2. IQ tests performed
3. Calibration
4. Supplier supplied documents
5. Equipment certificate
6. Installation deviations
7. Site Acceptance Tests (SAT)
8. Consumable list
9. Spare part list
10. Environmental review report
11. List of Operational and Instructional documents

IQ approval is a pre-requisite for the start of the Operational Qualification (OQ) phase.

## PHASE THREE: OPERATION QUALIFICATION

The objective for this Operational Qualification (OQ) phase is to show through objective evidence that the cleanroom operates in conformance with design requirements and user defined requirements, and that it consistently operates within a defined range of conditions.

The OQ protocol should address the following:

- Testing HVAC (Heating-Ventilation-Air Conditioner) system operation against specified functional requirements
- Critical Alarms
- Interlock Alarms
- Critical operating parameters defined on the room data sheet
- Filter integrity tests
- Standard operation for the cleanroom
- Air speed and air flow
- Air flow patterns
- Pressure differential

The OQ phase should also address worst case scenarios. To design the worst case scenario for the operation of the cleanroom, critical operating parameters are identified from the cleanroom data sheet. Operation ranges, and extreme ranges, are set for each critical parameter and a worst case designed and documented. It should include the following:

1. Maximum and minimum temperatures
2. Maximum and minimum humidity
3. Maintenance schedules
4. Personnel contamination

The worst case scenario is usually carried out at the specified High and specified Low parameters.

The output of this phase is an OQ report addressing alarms and functional requirements of the cleanroom specified in the user requirement specifications.

## PHASE FOUR: PERFORMANCE QUALIFICATION

The purpose of Performance Qualification (PQ) of the cleanroom is to demonstrate with objective evidence that the cleanroom consistently operates within defined parameters to produce the defined, desired environmental outcome. Cleanroom performance qualification involves testing and monitoring of the following:

1. Airborne particulate levels
2. Surface particulate levels
3. Viable microbial particulates
4. Relative humidity
5. Differential pressure
6. Temperature

The output of the PQ phase is a PQ report that analyzes the performance of the cleanroom using specified equipment parameters. PQ is a pre-requisite for certification.

| CLASS | Number of Particles per Cubic Meter by Micrometer Size | | | | | |
|---|---|---|---|---|---|---|
| | 0.1 um | 0.2 um | 0.3um | 0.5 um | 1 um | 5 um |
| ISO 1 | 10 | 2 | | | | |
| ISO 2 | 100 | 24 | 10 | 4 | | |
| ISO 3 | 1,000 | 237 | 102 | 35 | 8 | |
| ISO 4 | 10,000 | 2,370 | 1,020 | 352 | 83 | |
| ISO 5 | 100,000 | 23,700 | 10,200 | 3,520 | 832 | 29 |
| ISO 6 | 1,000,000 | 237,000 | 102,000 | 35,200 | 8,320 | 293 |
| ISO 7 | | | | 352,000 | 83,200 | 2,930 |
| ISO 8 | | | | 3,520,000 | 832,000 | 29,300 |
| ISO 9 | | | | 35,200,000 | 8,320,000 | 293,000 |

Table 1: Airborne Particulate Cleanliness Classes (by cubic meter)

## CLEANROOM CERTIFICATION

Validated cleanrooms are validated to a required class of cleanliness. The level of cleanliness chosen is driven by user requirements. Cleanroom classes are defined in ISO1464-1:

Methods for evaluation and measurements for Certification are specified in ISO14644-3. It calls out for the following ten tests.

1. Airborne particle count test
2. Airflow test
3. Air pressure differencial test
4. Filter leakage test
5. Flow vizualization test
6. Airflow direction test
7. Temperature test
8. Humidity test
9. Recovery test
10. Containment leak test

Once certified to a particular class the cleanroom factors are monitored to ensure that parameters have not drifted, or changed, and that the environment is under control.

| Schedule of Tests to Demonstrate Continuing Compliance | | | |
|---|---|---|---|
| Test Parameter | Class | Maximum Time Interval | Test Procedure |
| Particle Count Test | <= ISO 5 | 6 Months | ISO 14644-1 Annex A |
| | > ISO 5 | 12 Months | |
| Air Pressure Difference | All Classes | 12 Months | ISO 14644-1 Annex B5 |
| Airflow | All Classes | 12 Months | ISO 14644-1 Annex B4 |

Table 2: Required Testing (ISO 14644-2)

## MONITOR AND CONTROL

A constant monitoring program is required after certification. Requirements for compliance are found in ISO 14644-2.

Statistical analysis for cleanroom parameters is encouraged as a tool for monitoring the cleanroom after certification to ensure compliance. The tool of choice is statistical process control, SPC.

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