(This annex is not a mandatory part of the referring ASHRAE SSPC 300 standard or guideline. It is merely informative and does not contain requirements necessary for conformance to the standard or guideline.)

(The following informative annex is provided to illustrate, explain, or support the ASHRAE SSPC 300 commissioning process. The information presented herein represents consensus good practice but does not contain mandatory commissioning process provisions. This informative annex supports more than one ASHRAE SSPC 300 commissioning standard or guideline and is not intended to serve as a standalone document. See the referring ASHRAE SSPC 300 standard or guideline for mandatory commissioning process requirements and guidance.)

ASHRAE SSPC 300 INFORMATIVE ANNEX 02—QUALITY BASED SAMPLING PROCESS

This informative annex provides an example of how to implement a sampling process within the commissioning process, if directed by the Owner.

02.1 Use of Sampling

Every Owner must make a conscious decision about whether to use sampling. The cost of a commissioning contract will be significantly affected by this decision. Using no sampling and checking all elements of commissioned systems in design, submittal, and construction reviews as well as testing, will result in the best level of quality assurance and the least defects. However, this also incurs the highest cost.

Choosing to use sampling will reduce the cost but will inherently result in a higher potential for undiscovered failures or conditions the Owner would reject had they been revealed in reviews or testing.

No empirical data are currently available regarding the success of sampling as a process, or the use of concrete sampling rates for equipment and systems installation in the building construction industry.

Factories producing equipment for the building industry may well use sampling in their production line quality process. The construction industry is different: the number of stakeholders involved in procurement, installation, and operation of equipment and systems is so large, and different for each project, that too many variables exist and therefore no empirical results are available that show performance of sampling methods for construction projects.

In this sense, sampling is used at the discretion of the Owner as a method of controlling budgets while accepting uncertainty about the quality of untested systems or equipment. It may be prudent for the Owner to include several sampling schemes in the request for proposal (RFP) for a Cx Provider (CxP) (also refer to Informative Annex 3, "Initiating the Commissioning Process"). This would allow pricing to be obtained for 100% testing (no sampling) and alternate pricing for a sampling regimen that the Owner feels would provide a reasonable level of risk. Thus, a price reduction from the CxP could be weighed against the risk of having some elements of the building operating incorrectly.

The use of sampling in the construction review processes will be defined in the Owner's Project Requirements (OPR). Sampling processes should be used only as defined in the Owner's Project Requirements (OPR) and/or with the specific agreement of the Owner. The Cx Plan can also add requirements and information to the design review process and procedures.

The Owner's understanding of quality-based sampling and level of assurance desired will typically have the greatest influence on the sampling rates utilized (see Tables 02-1 through 02-3, Note 2).

The CxP's understanding of quality-based sampling and the Cx also impacts the sampling rate (see Tables B-1 through B-3, Note 3).

This informative annex describes the use of sampling in four process steps typically included in a Cx:

a. Sampling in design review
b. Sampling in submittal review
c. Sampling in site visits for construction progress review
d. Sampling in Cx testing

02.2 Sampling in Cx Design Review

A critical step in the Cx is the review of the design submissions from the design professionals. It is important to remember that the role of the CxP is to verify that the OPR is met and that the sampling is used in the design review as defined in the OPR. A review of the specifications is also a part of the commissioning process.

The use of sampling in a review of design documents (plans and specifications) should focus on two main areas:

a. The criteria from which to accomplish the general review of the submission should be documented. The criteria should be based on general quality characteristics and specific OPR criteria. The general quality characteristics should include items such as the following items shown as an example (actual characteristics for review will be project specific):

- Continuation of items (ductwork, pipes, etc.) from page to page
- Labeling, including correct room numbering
- Details corresponding to actual components
- Schedules including BoD information
- All information legible (not hidden by crossing lines or text)
- OPR information is included on drawings
- Evaluating using explicit review criteria as defined in the OPR

b. Use the sampling method defined in the OPR, or define a sampling method for the review, to give the readers of the review an idea of the breadth of data reviewed.

There are no generally accepted sampling methods or sampling rates for a Cx Design Review process in the building commissioning industry. There are many sampling-related ANSI and ISO standards, but most relate to physical products rather than the processing of design review.

Refer to Informative Annex 08, "Design Review and Report," for details on the contents of a Cx Design Review. The criteria for design review listed in Informative Annex 08 should be employed where relevant, e.g., life-cycle cost (LLC) analysis review is possible only if an LLC analysis was performed as part of the design. This means no sampling should be employed when considering which Cx Design Review criteria to use.

However, depending on the definition of each review criterion, it is possible that sampling is appropriate to verify the quality of the design. Three examples are shown below, one for a mechanical system, one for an electrical system, and one for coordination. Many other examples exist, and all will be system-specific.

EXAMPLE—MECHANICAL DESIGN REVIEW SAMPLING

Criterion: Air Terminal Selection

Procedure: Check the count and size of variable-air-volume terminal (VAV) selection on a project, one of the most typical components in a mechanical system.

Count: Verify that the equipment schedule lists the same number of terminals as shown on drawings (no sampling).

Sizing: Verify that the scheduled VAV airflow matches the airflow at diffuser outlets. Verify that the size of resulting in VAV terminal results in a pressure drop and noise generation no higher than the limits allowed in OPR, Basis of Design (BoD), or specifications.

Sampling: Check 15% of scheduled terminals and a minimum of five terminals. Where an error is encountered, check an additional 15% of terminals and repeat the process until either all terminals are checked, or no further errors are found. Where the terminal selection and sizing are available in industry-standard electronic format, no sampling shall be used, and checksums in formulas should be used to verify sizing.

EXAMPLE—ELECTRICAL DESIGN REVIEW SAMPLING

Criterion: Feeder Sizing

Procedure: Check the size of a feeder by identifying all loads connected to breakers in one panel and verifying on the panel schedule that the loads are reflected correctly. Check the resulting combined panel load and verify that the conductor sizing for the feeder is in compliance with NEC and specification requirements.

Sampling: Perform the procedure on 15% of the scheduled panels and a minimum of three panels. Where an error is encountered, check an additional 15% of panels, and on repeat failure, stop the process and return to the designer with a notice that too many errors exist and that the document must be resubmitted. Where the panel selection and conductor sizing are available in industry-standard electronic format, no sampling shall be used, and checksums in formulas shall be used to verify sizing.

EXAMPLE—COORDINATION REVIEW SAMPLING

Criterion: Spatial fit for all systems combined

Procedure: Accomplish Coordination Review: For each area, compare the squares between each discipline. The intent of this review is to identify coordination problems with the placement and installation of components. Items of specific interest include the following:

a. Placement of multiple pieces of equipment/components in the same location
b. Accessibility to equipment/components for maintenance/replacement
c. Use of consistent terminology (e.g., room numbers)
d. Elevations provided where multiple systems are placed in the same area
e. Other trade duties clearly identified (e.g., electric wiring for HVAC equipment, holes for sinks)

Sampling: Determine Sampling Areas: For each floor plan area (i.e., if there are five sheets for each floor, then there are five floor plan areas for each floor), select a single 10 × 10 in. (250 × 250 mm) square randomly. A simple way to do this is to divide the drawing sheet into 15 squares (5 × 3) and select square number 3 on the first sheet (area), and then 5, 7, etc., for each remaining area. This selection is accomplished typically using the architectural sheets.

Select Review Samples on Drawings: Using the sampling strategy chosen in Step 1, mark the sample areas to be reviewed in each area. This should be accomplished for each trade (landscaping, architectural, structural, plumbing, mechanical, electrical, etc.).

NOTE: It is possible with today's technology, to demand that all spatial coordination (clash detection) be executed without sampling. This requires all stakeholders to use compatible design tools and requires that someone conduct the coordination review for space/fit criteria. This is often the MEP coordinator for the general contractor, so that a coordination review is then executed by the CxP in the design phase using sampling (and all of the criteria listed above), and during the shop drawing phase by the MEP coordinator without sampling (checking for space/fit criterion). The OPR in this case may contain a requirement to execute coordination reviews and clash detection. The Cx Plan includes an assignment of responsibilities for who executes which step.

02.3 Sampling in Submittal Review

The sampling process to be followed by the CxP in evaluating the contractor's submittals is similar to sampling in a Cx Design Review process:

a. **Document the General Review Criteria.** The criteria from which to accomplish the general review of the submission must be documented. The criteria should be based on general quality characteristics and specific OPR criteria. The general quality characteristics should include items such as those listed below as an

example (actual characteristics for review will be project specific). Where design drawings and specification have been approved in a prior review step (refer to Section 02.2, "Sampling in Cx Design Review" above), the submitted equipment should now meet both explicit OPR criteria and also meet selections defined in approved drawings and specifications. Example criteria include:

- Performance of submitted equipment and systems (power, flow, pressure, wind resistance, noise)
- Size and weight
- Access (orientation, door size, clearances, handles/latches)
- Materials (material type, thickness, production method)
- Surface treatments (paint, coatings, protection)

b. Use the sampling method defined in the OPR, or define a sampling method for the review, to give the readers of the review an idea of the breadth of data reviewed.

Refer to Informative Annex 09, "Submittal Review and Report," for details on the contents of a submittal review. The criteria for design review listed in Informative Annex 09 should be employed where relevant. This means no sampling should be employed when considering which design review criteria to use, although sampling may be employed within each criterion; in the above list, "materials" is given as a criterion to be checked. This means for every submitted piece of equipment which is checked, the material characteristics should be examined. Checking a piece of equipment without examining its materials would not be acceptable. However, not every piece of equipment needs to be examined; it is possible to define a 10% sampling rate, and review only a subsection of equipment.

Depending on the definition of each review criterion, it is possible that sampling is appropriate to verify the quality of the design. Two examples are shown below: one for a building automation system submittal, and one for a mechanical system. Many other examples exist, and all will be system specific.

EXAMPLE—BUILDING AUTOMATION SYSTEM (BAS)

Criterion: Point Naming and Wiring Schematics

Procedure: Check the point nomenclature of a control point at the sensor and follow the wiring diagram to the input or output terminal of a particular controller. Where this path spans several drawings, as is typical, verify that the naming convention is consistent. For example, where an AHU schematic refers to "AHU-3 SAT" for the supply air temperature sensor input, the controller drawing refers simply to an input "C7 Ai9," and the point table refers to "AHU Temp1" (10k thermistor), a correction would be required to make nomenclature consistent.

Ensure that continuity is maintained from one drawing to the next. For example, a consistent use of wiring continuity is where an AHU schematic supply air temperature sensor wire ends with a tag "23/C.3.201," and drawing C.3.201 shows a tag "23/C.2.110" whose wire leads to a terminal block at the control panel labeled "AHU-3 SAT," where sheet C.2.110 is the AHU diagram.

Sampling: Check 5% of control points with a minimum of five control points. Where an error is encountered, check an additional 5% of control points, and repeat the process until either all terminals are checked, or no further errors are found. Where a drawing is typical for a particular component, the points shown on that drawing will be counted only once for the sampling percentage calculation. For example, a typical cooling-only VAV terminal drawing shows six control points, and the project contains one hundred such terminals. The requirement in this case would be to check six points, not six hundred.

EXAMPLE—MECHANICAL SYSTEM, AIR TERMINAL SUBMITTAL

Criterion: Capacity Check

Procedure: Check the capacity of submitted air terminal units against the approved contract drawings that were previously reviewed against the OPR and BoD in Cx Design Reviews. Air terminals may be submitted either explicitly in a table listing all terminals, by copying the drawing equipment schedule, or in a format where one terminal size is shown with a marker, such as "Terminal type xyz, size 10 in. for VAV-1-12 to 1-17, 1-30, 1-42, and 2-8, 2-10, 2-15 to 2-27," without explicitly confirming sizing, airflow, noise, and pressure drop for each terminal.

Sampling: If the submitted make/model of terminal matches the scheduled make/model, check 10% of terminals, and a minimum of five terminals, to verify that the procedure used by the vendor correctly matches the equipment schedule and submitted terminals. If the submittal is for a substitution of make or model, check 20% of terminals, and a minimum of ten terminals, and include verification of radiated and duct sound pressure levels, total pressure drop at design flow, and flow pickup amplification factor (for airflow turndown) to ensure they match or exceed the originally specified criteria. Where an error is encountered, check an additional 5% of control terminals, and repeat the process until either all terminals are checked, or no further errors are found. Where the terminal submission data are available in industry-standard electronic format, no sampling shall be used, and checksums in formulas shall be used to verify the criteria described above.

TABLE 02-01 Sample Rate Determination—Submittals

Factor	Guidance	Sample Rate (% of Components or % of Pages)
Complexity	Components of greater complexity typically require additional maintenance space and access points, as well as have a greater likelihood of involving multiple OPR criteria. Therefore, with greater complexity, the rate of sampling typically increases.	Higher sampling rates (more elements reviewed) for higher complexity
Criticality	As the criticality of a component increases relative to achieving the OPR, the sampling rate increases to provide a higher level of assurance that the OPR will be achieved. For example, in a data processing center where any downtime results in the loss of significant revenue, there is an obvious need for increased review as compared to a retail clothing store.	Higher sampling rate (more elements reviewed) for more critical systems
Length	A submittal that has very little information (length) will typically result in a high sampling rate, whereas one with hundreds of pages will typically result in a low sampling rate of the submittal document. For noncritical components, a random subset of the evaluation criteria may be used.	Higher sampling rate (more elements reviewed) for shorter submittals

Notes:

1. For sampling rates greater than 100% (e.g., extremely critical laboratory equipment that results in loss of life if it fails), the approach is that two independent reviewers using different instrumentation accomplish their evaluation following the documented test procedures. Therefore, if a 400% review is warranted, then there would be four independent reviewers.
2. It is important to understand that even if the sampling rate is 100% or greater, the approach to be taken is still one of random sampling. For example, for a facility that has 40 rooms, the test to verify the comfort OPR would use a random approach of first checking rooms 100, 105, 110, 115, then rooms 101, 106, 111, 116, etc. This random approach enables an unbiased evaluation of the comfort throughout the facility relative to the OPR. If issues are identified early in the testing process (e.g., after a 20% testing, systemic issues have been identified), then there is no reason to accomplish the other 80% of the testing, as it has been shown that the system does not achieve the OPR, and something needs to be changed.
3. Because the final Cx tests to verify OPR achievement, it should focus on specific OPR criteria, and the skills of the CxP in developing appropriate, tailored tests may greatly impact the sampling rate required to determine OPR achievement.

02.3.1 Accomplish Review. With the evaluation criteria established, the submittal review is accomplished. Since the sampling rate directly impacts the level of effort required by the CxP, the sampling rate should be determined during scope negotiation between the Owner and CxP. During these negotiations, it is important to remember that it is the contractor's duty to create 100% of the required submittals, and it is the design professional's duty to review 100% of the submittals. It is the CxP's role to evaluate the contractor's and the design professional's work relative to OPR achievement. It is important to a successful Cx to maintain complete records of the review findings for both items that meet the criteria (especially the OPR) and items where deficiencies are noted throughout the entire review process.

02.4 Sampling in Construction Progress Reviews

The contractor is responsible for installing and, where applicable, starting up 100% of the building systems and assemblies. The design professional is responsible for verifying adherence to the project design and specifications. It is the CxP's responsibility to accomplish ongoing verification that the contractor's work achieves the requirements of the design plans and specifications, as well as the OPR. This may be accomplished through quality-based sampling of construction progress.

There are several sampling rates that should be defined in this context, for data gathering and for review. The rate at which site records are compiled (sampling over time) and the means by which they are compiled (two-dimensional photographs, 360 degree photos or video, point clouds produced by a portable laser scanner) should be described. The Cx Plan should also include responsibilities for executing such record gathering. This can be accomplished by the general contractor on a weekly basis; for example, by each trade with a focus on

their installed systems, by the CxP Team at periodic intervals with a focus on commissioned systems, or a combination of all of these.

EXAMPLE—SITE PROGRESS RECORD COLLECTION, CONCEALED SERVICES

Criterion:	Concealed services records
Procedure:	General contractor collects pre-inspection photographs of all concealed services. Records are kept for every such location without sampling, including plumbing, radiant piping in slabs, electrical wiring within walls, etc.
Sampling:	**Systems:** 100% of all concealed services **Time:** As applicable, showing completed system just before concealment for 100% of systems
Responsible Party:	General contractor to produce records, CxP to verify their existence and copy to Systems Manual. CxP to attend 10% of inspections before concealment

EXAMPLE—SITE PROGRESS RECORD COLLECTION, OVERALL SCHEDULE VERIFICATION

Criterion:	Overall site progress for verification that completion schedule is being maintained
Procedure:	General contractor collects whole-site hourly progress pictures from two cameras at the north and south end of the site, respectively. Photographs shall be automatically uploaded to a website and available in real time to all project stakeholders with the ability to scroll through time from beginning of project to current.
Sampling:	**Systems:** Those visible from agreed upon camera locations **Time:** Hourly
Responsible Party:	General contractor to produce records, CxP to verify their existence and copy to Systems Manual

EXAMPLE—INSTALLATION OF MECHANICAL SYSTEM

Criterion: Installation of mechanical systems according to approved design documents.

Procedure: CxP shall record installation progress of all central equipment (AHU's, chillers, towers, pumps, heat exchangers, boilers) using 360 degree photography to allow review of each piece of equipment from all sides.

CxP shall also record nameplate information by photograph of all central equipment. CxP shall record installation progress of distributed equipment (VAV terminals, fan-coil units) using 360 degree photography to document location, installation clearances, and service access.

Progress records shall be provided on a monthly basis and made available in real time to all Project Team members in a cloud-based system that shows photographs in a standard browser, allows review of 360 degree photos with appropriate viewer, shows photos linked to their respective locations in the latest version of floor plans, and allows stakeholders to review construction status over time by scrolling through records taken in a location over previous months.

Sampling: **Systems:** CxP shall use a 100% sampling rate to record central equipment and 30% sampling rate to record distributed equipment as defined above. Where more than 5% of equipment show installation deficiencies leading to issues log items, sampling size shall be increased to 10%.

Time: 100% of shipments shall be logged, at the time of arrival.

EXAMPLE—ACCEPTANCE OF EQUIPMENT AND COMPONENTS

Criterion: Tracking elements of construction for commissioned systems which have arrived and been rejected or accepted

Procedure: General contractor shall keep a log of materials received on site, including date, shipper ID, bill of lading, and signature of person who accepted shipment for all commissioned systems. For rejected shipments, photos shall be recorded showing damage and reason for rejection. Any rejection records for elements of commissioned systems shall be transmitted to the CxP for inclusion in the issues log.

Sampling: **Systems:** 100% of discrete equipment listed on an equipment schedule shall be checked and either accepted or rejected. All elements of systems not uniquely identified, such as steel beams, glazing, concrete, piping, ductwork, fittings, cabling, conduit etc., shall undergo a 5% sampling per shipment to verify compliance with contract documents.

Time: 100% of shipments shall be logged, at the time of arrival.

EXAMPLE—INSTALLATION OF ENVELOPE SYSTEMS

Criterion: Building enclosure integrity

Procedure: Check the continuity of building enclosure air, water, and thermal barriers; compatibility of materials used to construct the building enclosure; suitability for climate of the geographical location of the project.

Sampling: Perform evaluation of all building exterior details from a functional performance perspective and develop specifications for progressive testing of building enclosure components, including sampling strategies that have been defined in the OPR and approved by the Owner. Common practices include 100% testing of mockups and first in-situ installation of the building enclosure components that define a portion of the building enclosure system. Sampling percentages of similar building enclosure elements is dependent on the quantity of those elements. The larger the number of common elements, the smaller the required quantity of functional tests, and the smaller number of common elements, the larger percentage of functional testing required. A building with twenty windows could have a requirement to test 50% of the building windows, with a requirement to perform additional testing of equal sample size of the remaining building windows. A project with four hundred windows could limit testing of windows to 10% of the building windows, and equal size of additional testing in the event of failure within the original sample.

The sampling rate to be used during a particular site visit depends on the factor in Table 02-02, "Sample Rate Determination—Construction Verification." The table provides general guidance for components. This may not apply to assemblies and systems that support larger-scale or integrated systems or assemblies, and/or if they are not part of the Cx scope. For example, if the envelope is not included in the scope of the Cx for a specific building, there will not be any checklists for the envelope components, and the envelope will not be included as a site visit item to be checked to evaluate the quality of the envelope as it impacts the performance of other systems or assemblies.

TABLE 02-02 Sample Rate Determination—Construction Verification

Factor	Guidance	Sample Rate (% of Components or % of Pages)
First Completed Construction Checklist	It is recommended that for the first construction checklist to be completed by the contractor for a particular component assembly type, it should be verified and reviewed with the contractor to improve their understanding of the importance of completing all checklists as the work progresses, and to eliminate systemic issues before they become problems. This is recommended, even though it will be included in the preconstruction Cx session.	No sampling
Pace of Construction, Number of Scheduled Activities	Construction verification does not have to happen on a fixed interval (such as weekly or monthly). It is possible to verify construction at specific points in progress (such as inspections that occur before utilities are covered up). If such an approach is chosen, the agreement may be that five construction inspections occur, at predetermined progress points or scheduled activities. In a fast-paced schedule, this might mean weekly reviews over five weeks. In a long schedule, this may mean five inspections over ten months. This difference may appear to be a difference in sampling intervals (weekly or bi-monthly), but it really presents the same level of review. In addition, there may in fact be real sampling differences, such as a decision to sample progress five times or ten times for the same scheduled activities, in which case the first option clearly represents a lower sampling rate both over time and over construction activities.	Somewhat dependent on the definition of sampling (related to time or to scheduled activities) Higher sampling rate (more elements reviewed) for more complex systems
Number of Components	If there is only one instance of a component, the rate of sampling is typically 100%, and where there are many similar components, the sampling rate decreases	Higher sampling rate (more elements reviewed) for fewer components

Notes:

1. For sampling rates greater than 100% (e.g., extremely critical laboratory equipment that results in loss of life if it fails), the approach is that two independent reviewers using different instrumentation accomplish their evaluation following the documented test procedures. Therefore, if a 400% review is warranted, then there would be four independent reviewers.
2. It is important to understand that even if the sampling rate is 100% or greater, the approach to be taken is still one of random sampling. For example, for a facility that has 40 rooms, the test to verify the comfort OPR would use a random approach of first checking rooms 100, 105, 110, 115, then rooms 101, 106, 111, 116, etc. This random approach enables an unbiased evaluation of the comfort throughout the facility relative to the OPR. If issues are identified early in the testing process (e.g., after a 20% testing, systemic issues have been identified), then there is no reason to accomplish the other 80% of the testing, as it has been shown that the system does not achieve the OPR, and something needs to be changed.
3. Because the final Cx tests to verify OPR achievement, it should focus on specific OPR criteria, and the skills of the CxP in developing appropriate, tailored tests may greatly impact the sampling rate required to determine OPR achievement.

02.5 Sampling in Cx Testing

Testing of commissioned systems can take a variety of forms and should be described in the OPR. Some examples of testing scope are described in Table 02-03, "Sample Rate Determination—Final Functional Performance Testing." Also refer to Informative Annex 10, "Construction Observation and Testing Checklists and Reports," for definitions of test methods and differences between active and passive tests.

EXAMPLE—SOLAR PV ARRAY

Criterion: Verify solar cell output

Procedure: CxP shall review expected power production of solar cell against actual power production.

Sampling: **Systems:** 5% of panels shall be checked upon substantial completion using hand-held meters. 100% of panels shall be checked using Building Automation System (BAS) data of transmitted power.

Time: One initial single-point set of data shall be taken upon substantial completion. 24 hours of data at 15-minute intervals shall be taken on a cloudy day. 24 hours of data at 15-minute intervals shall be taken on a sunny day.

EXAMPLE—WINDOW LEAK TIGHTNESS

Criterion: Verify windows are installed without leakage during rain.

Procedure: CxP shall conduct window spray test with the assistance of the general contractor.

Sampling: **Systems:** Windows shall be checked upon installation of the first 5% of each type. 100% of these initially installed windows shall be tested before remaining windows are installed. 5% of remaining windows shall be randomly tested after substantial completion of entire envelope.

Time: Initial 5% check shall occur as soon as the first 5% of windows are installed. Remaining windows shall be checked as contractor signals readiness after installation of all remaining windows.

Each of these examples yield different results and different costs. The method to be employed may vary by type of system and should be discussed with the Owner and recorded in the OPR before designs are completed; the degree to which access and instrumentation are required for testing may affect the design. Using sampling reduces cost but can also increase risk to the Owner.

TABLE 02-3 Sample Rate Determination—Final Functional Performance Testing

Factor	Guidance	Sample Rate (% of Components or % of Pages)
Complexity	The greater the complexity of HVAC&R system and interaction of OPR between multiple components; typically, the more additional evaluation and testing is required to verify the OPR achievement. Therefore, with greater complexity, the rate of sampling typically increases.	Higher sampling rate (more elements reviewed) for more complex systems
Criticality	As the criticality of a component increases, relative to achieving the OPR, the sampling rate increases to provide a higher level of assurance that the OPR will be achieved. For example, a data processing center where any downtime results in the loss of significant revenue, there is an obvious need for increased testing, compared to a retail clothing store (also refer to Note 4 below).	Higher sampling rate (more elements reviewed) for more critical systems

Notes:

1. For sampling rates greater than 100% (e.g., extremely critical laboratory equipment that results in loss of life if it fails), the approach is that two independent reviewers using different instrumentation accomplish their evaluation following the documented test procedures. Therefore, if a 400% review is warranted, then there would be four independent reviewers.
2. It is important to understand that even if the sampling rate is 100% or greater, the approach to be taken is still one of random sampling. For example, for a facility that has 40 rooms, the test to verify the comfort OPR would use a random approach of first checking rooms 100, 105, 110, 115, then rooms 101, 106, 111, 116, etc. This random approach enables an unbiased evaluation of the comfort throughout the facility relative to the OPR. If issues are identified early in the testing process (e.g., after a 20% testing, systemic issues have been identified), then there is no reason to accomplish the other 80% of the testing, as it has been shown that the system does not achieve the OPR, and something needs to be changed.
3. Because the final Cx tests to verify OPR achievement, it should focus on specific OPR criteria, and the skills of the CxP in developing appropriate, tailored tests may greatly impact the sampling rate required to determine OPR achievement.
4. Some testing creates risk, such as failure testing in a partially occupied hospital or in a data center expansion. Testing whether the chilling plant controls correctly respond to the failure of a chiller carries the risk that cooling is interrupted if the expected response does not occur. An Owner may decide that this risk is too great, and particular tests are delayed until an annual shutdown, or not executed at all.
5. The following serve as examples of sampling strategies:
   a. Sampling: Multiple identical pieces of non-life-safety or otherwise noncritical equipment may be functionally tested using a sampling strategy. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference.
      i. A common sampling strategy, referenced in the specifications as the "xx% Sampling–yy% Failure Rule," is defined by the following example.
         (1) xx = the percent of the group of identical equipment to be included in each sample
         (2) yy = the percent of the sample that, if failing, will require another sample to be tested
      ii. The example below describes a 20% Sampling–10% Failure Rule.
         (1) Randomly test at least 20% (xx) of each group of identical equipment. In no case test fewer than three in each group. This 20%, or three, constitute the "first sample."
         (2) If 10% (yy) of the units in the first sample fail the functional performance tests, test another 20% of the group (the second sample).
         (3) If 10% of the units in the second sample fail, test all remaining units in the whole group.
         (4) If at any point frequent failures occur, and testing becomes more troubleshooting than verification, the CxP may stop the testing and require the contractor to perform and document a checkout of the remaining units prior to continuing the functional testing.
   b. For building elements that are duplicated many times throughout the building (e.g., windows, light fixtures) or cover large areas or sections of the building (e.g., wall insulation), the specific protocol identifies the minimum required area or sample to be inspected. If the minimum sample is inspected with a 100% compliance rate, then the inspection process is complete. If a failure is detected within the sample set, corrective actions should be implemented, and the sample retested.