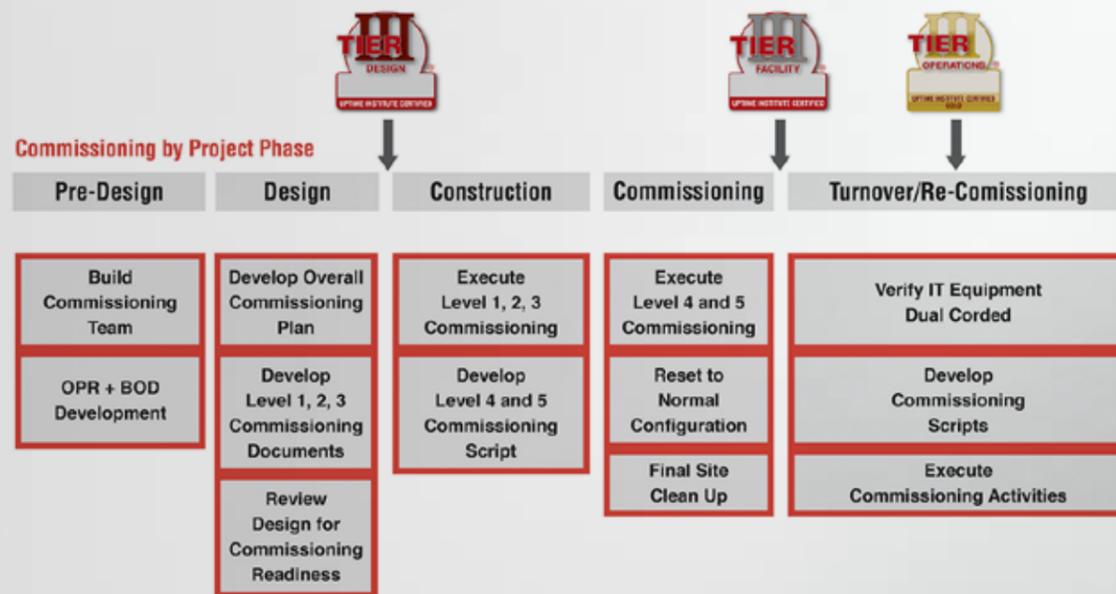


Commissioning Mission Critical Facilities

A LOOK AT THE COMMISSIONING REQUIREMENTS OF DATA CENTERS

By Ryan Orr, with Chris Brown and Ed Rafter

Many data center owners and others believe that commissioning takes place only in the last days before a facility enters into operation. In reality, commissioning should begin at project inception and continue through the life of the data center (see Figure 1).



^ Figure 1 Commissioning ensures that the data center functions as designed throughout the life of the data center.

Uptime Institute’s extensive experience reveals that many of the problems, and subsequent consequences, observed in operational facilities could have been identified and remediated during a thorough commissioning process. Rigorous, comprehensive Level 5 commissioning reduces initial failure rates, ensures that the data center functions as designed, and verifies facility operations capabilities.

Commissioning:

- > Verifies that equipment and systems operate as designed
- > Provides a baseline for how the facility should perform
- > Affords the best opportunity for Operations to become familiar with how systems operate without risking critical IT loads
- > Determines the performance limits of a facility

COMMISSIONING BASICS

Many organizations have tried to define the process of commissioning using terminology that categorizes commissioning activities in five levels (see Figure 2).

The owner should initiate the commissioning process at the project outset, including identifying key stakeholders to take part in the program. The owner, contractor, architects and engineer, Operations, and the commissioning agent (CxA) are usually the most critical stakeholders on any project. Ideally the CxA is an independent third party and is responsible for planning and executing of the entire commissioning process. The CxA should ensure that the roles and responsibilities of the other stakeholders are balanced and well documented.

| | | |
|---------|--|---|
| LEVEL 1 | Factory Witness Testing (FWT) | FWT verifies operation and capacity for the components that are to be installed in the data center, including engine-generator sets, UPS systems, chillers, air conditioners, and switchgear. FWT is carried out in the original equipment manufacturer's (OEM) factory or in a third-party testing facility. These testing activities should be witnessed by at least one representative of the project team. FWT is performed with conditions and procedures that are in accordance with manufacturer, national, or international standards, as well as the owner's individual needs. Testing these components in the factory also helps prevent irreparable components, particularly in long-lead items, from reaching the job site. OEMs must correct the testing failures prior to shipment. FWT reports are generated by the OEM or third-party testing laboratory, provided to the client and Engineer-of-Record, and reviewed by the design and commissioning team. |
| LEVEL 2 | Receipt, installation, post-installation checks | Receipt checking includes inspecting the products upon delivery to the site to ensure the equipment delivered matches what was procured and tested during Level 1 and that the product has not been damaged or altered during shipment. Installation and post-installation checking includes verifying that each and every component and auxiliary appurtenance has been installed in accordance with drawings, plans, and specifications; accessibility; maintainability; health and safety requirements; local codes; and OEM installation requirements and directives. |
| LEVEL 3 | Functional component testing (FCT) | FCT verifies that the installed component is operable at a basic level. This includes maintaining checklists for mechanical and electrical equipment start-up. FCT often also includes initial performance verification by an OEM representative, which typically starts the warranty period. Mechanical systems should go through a pre-test, adjust, and balance (TAB) effort to ensure accuracy for Level 4 commissioning. |
| LEVEL 4 | Functional system testing (FST) | FST verifies that each system is ready to be integrated with other systems supporting the data center. During FST, the CxA typically performs the TAB of the mechanical systems to ensure design airflow and water flow rates are achieved. The FST includes load related tests that ensure that related components, equipment, and ancillaries of a defined system operate and function to acceptance criteria. This should include normal, maintenance, and emergency modes of operation to verify settings, alarms, capacities, and performance of associated monitoring and control functions. |
| LEVEL 5 | Integrated system testing (IST) | IST ensures that all of the various data center systems work together under a variety of load conditions as designed. IST verifies the systems' responses to various actions, maintenance activities, or faults, as per the design Sequences of Operation. The testing of interrelated components and system verifies that each component and system as a whole will respond as intended to expected and unexpected events. |

^ Figure 2 Uptime Institute notes that Level 5 commissioning includes prescribed tasks to be performed in logical order.



| | OWNER OR OWNER'S REPRESENTATIVE | CONTRACTOR | ARCHITECTS AND ENGINEERS | OPERATIONS TEAM | COMMISSIONING AGENT |
|---|---------------------------------|------------|--------------------------|-----------------|---------------------|
| Develop RFP for CxA | X | | | X | |
| Select CxA | X | | | X | |
| Establish a commissioning team with key stakeholders | X | X | X | X | X |
| Include commissioning in the overall project schedule | X | X | | | X |
| Identify the budget for commissioning | X | | | | X |
| Develop OPR documentation | X | | X | X | X |

^ Figure 3 During the pre-design phase, the project owner initiates commissioning, selects the CxA, and participates in building the commissioning team and budget.



v Figure 4 The design and pre-construction phases are commonly blended — some activities are completed concurrently.

| | OWNER OR OWNER'S REPRESENTATIVE | CONTRACTOR | ARCHITECTS AND ENGINEERS | OPERATIONS TEAM | COMMISSIONING AGENT |
|--|---------------------------------|------------|--------------------------|-----------------|---------------------|
| Develop commissioning plan | | | | | X |
| Review commissioning plan | X | X | X | X | |
| Review design for OPR concurrence | X | X | | X | X |
| Review design for operations concurrence | X | | | X | X |
| Review design for operations readiness | X | X | | X | X |
| Develop commissioning plans, checklists, and reports for Level 1, 2, and 3 | | X | | X | X |
| Review commissioning plans, checklists, and reports for Level 1, 2, and 3 | X | X | X | X | X |

PRE-DESIGN PHASE

Pre-design phase commissioning begins with selection of a CxA through a request for proposal (RFP). During the pre-design phase, the owner, Engineers-of-Record, Operations, and the CxA identify the owner's project requirements (OPR) for the data center (see Figure 3).

These tasks include developing a project schedule that includes commissioning, creating a budget, outlining a commissioning plan, and documenting the OPR and basis of design (BOD). Selecting the CxA in the pre-design phase allows it to help develop the OPR and BOD, the commissioning program, the budget, and schedule.

DESIGN AND PRE-CONSTRUCTION

The design and pre-construction phases are commonly blended into a design/build format in which some activities are completed concurrently (see Figure 4). At this time, the CxA will take the lead in developing the commissioning plan, which is the heart of the commissioning program. Other stakeholders should review and participate in the approval of the final commissioning plan.

The overall commissioning plan generally includes:

- > Scope
- > General schedule
- > Documentation requirements
- > Risk identification and mitigation plans
- > Required resources
- > Identification of the means and methods for testing
- > Design review for concurrence with the OPR and planned operations

CONSTRUCTION

The focus of commissioning moves from developing plans to execution during construction, with team members executing Level 1-3 activities. At the same time, the operations team and the CxA develop scripts for Level 4 and Level 5 (see Figure 5), with assistance and review from other team members.

In addition to these tasks, the CxA must also

- > Verify that circuit breakers are set in accordance with the short circuit and breaker coordination and arc flash study
- > Ensure that the building management system (BMS) functions at a basic level to support Level 4 and Level 5 commissioning activities

Throughout construction, the CxA monitors progress to ensure that the installations conform to the OPR. Once construction of the data center has been substantially completed, the CxA will lead the team through Levels 4 and 5 commissioning.

The purpose of these activities is to ensure that individual systems and the full data center ecosystem function as they were intended in the design and OPR documents (see Figure 6).

| | OWNER OR OWNER'S REPRESENTATIVE | CONTRACTOR | ARCHITECTS AND ENGINEERS | OPERATIONS TEAM | COMMISSIONING AGENT |
|---|---------------------------------|------------|--------------------------|-----------------|---------------------|
| Execution of Level 1 | X | | | X | X |
| Execution of Level 2 | X | X | | X | X |
| Execution of Level 3 | X | X | | X | X |
| Develop commissioning plans and scripts for Level 4 and 5 | | | | X | X |
| Review commissioning plans and scripts for Level 4 and 5 | X | X | X | X | X |

^ Figure 5 The operations team and the CxA develop scripts for Level 4 and Level 5.

Level 5 commissioning should test fault tolerant features, even when fault tolerance may not be a project requirement. Uptime Institute recommends testing as many scenarios as possible—even beyond the scope of design—to provide key information to operations about how to respond when the facility does not function and/or respond as designed. All critical components and systems must be fully tested—representative testing should not be acceptable.

Results from Level 4 and 5 commissioning should be extrapolated to predict performance at extreme design temperatures and conditions. In addition, commissioning should be scheduled seasonally to verify operation in extreme ambient conditions.



v Figure 6 Level 4 and 5 commissioning activities ensure that individual systems and the full data center ecosystem function as they were intended in the design and OPR documents.

| | OWNER OR OWNER'S REPRESENTATIVE | CONTRACTOR | ARCHITECTS AND ENGINEERS | OPERATIONS TEAM | COMMISSIONING AGENT |
|---|---------------------------------|------------|--------------------------|-----------------|---------------------|
| Execution of Level 4 | X | X | X | X | X |
| Execution of Level 5 | X | X | X | X | X |
| Final site cleanup | | X | | | |
| Ensure all equipment is back in normal position | | X | | X | X |

| | OWNER OR OWNER'S REPRESENTATIVE | CONTRACTOR | ARCHITECTS AND ENGINEERS | OPERATIONS TEAM | COMMISSIONING AGENT |
|---|---------------------------------|------------|--------------------------|-----------------|---------------------|
| Develop detailed commissioning scripts for all levels | X | | | X | X |
| Review commissioning scripts | X | X | X | X | X |
| Ensure IT hardware is dual corded (as required) | X | | | X | |
| Execute commissioning | X | X | X | X | X |
| Update SOPs, MOPs, and EOPs | X | | | X | |

^ Figure 7 Commissioning should be performed any time new infrastructure is installed or there is a significant change to the configuration of existing infrastructure.

TURNOVER-TO-OPERATIONS

The turnover-to-operations includes all activities associated with bringing the facility on line, including completing final documentation from Level 1-5 commissioning and utilizing the results to finalize SOPs, MOPs, and EOPs.

Soon after Level 4 and 5 commissioning, the facility will become live and Operations must take all of the knowledge gained from the construction and commissioning phases to finalize the maintenance and operations programs. Operations must complete this work relatively quickly to minimize risk to the data center.

The CxA should return approximately one year following the completion of commissioning to review the building operations and to resolve any items related to re-commissioning or seasonal commissioning efforts.

FUTURE INSTALLATIONS

In data centers that are built to be scalable, it is imperative that commissioning be just as rigorous for the follow-on infrastructure deployments to minimize risk to the facility. Commissioning activities undoubtedly add risk to the data center, especially where infrastructure systems are shared and supporting critical IT loads.

During re-commissioning or incremental commissioning, the Operations should be working in very close collaboration with the commissioning team. It is also critical that service owners receive adequate notice about the schedule, duration, risk, and countermeasures in place for the re-commissioning activities to gain concurrence from IT end users.



FOR MORE INFORMATION

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