Commissioning of Mission Critical Facilities

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Learning Objectives

1. Prepare and execute a pre-certification script, helping to assure a smooth certification process
2. Establish a detailed Roles and Responsibilities Matrix that will document the activities and level of involvement of all personnel involved in the certification of the laboratory and its systems
3. Compare and contrast commissioning of critical facilities and commissioning of non-critical facilities
4. Relate the “levels” of commissioning as they relate to the basic commissioning strategy of indentifying and resolving issues as early as possible
Agenda:

- Mission Critical- What are we talking about?
- How does it differ from ordinary commissioning
- Levels of Mission Critical Commissioning
- Document the “As-Built” Facility
- Train the Staff
- Wrap up Thoughts
What Does Mission Critical Mean

Failure of the facility would result in:

- Unacceptable loss of business operations
- Unacceptable customer inconvenience

May result in:

- High economic losses
- Loss of competitive advantage
- Possible loss of life in the most critical applications
Mission Critical Facilities

- Data Centers
- Trading Floors
- Medical – Life Support Systems
- Laboratory- Bio Safety Labs
- Air Traffic Control
- Electrical Power Distribution
- Railroad Traffic
Commissioning goals:

Mission Critical facilities:
- **Verify Performance**
  - Ability to cool
  - Ability to deliver at designed power levels
  - Ability to control loads
  - Ability to monitor systems
  - PUE (Energy Efficiency)
- **Verify Redundancies**
  - Component failure
  - Maintainability while operational
  - In 2N configurations—more than double the effort – verify interactions

Facility Commissioning:
- **Verify Performance**
  - Occupant comfort
  - Lighting
  - Energy Efficiency
- **Verify Redundancies**
  - Reasonable tolerance to component failure
  - Design intent is achieved
# Commissioning Phases:

(Enhanced Cx Items in Red)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activities</th>
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<tbody>
<tr>
<td><strong>PLANNING PHASE</strong></td>
<td>CDocuments&lt;br&gt;Plan Commissioning Process</td>
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<tr>
<td><strong>DESIGN PHASE</strong></td>
<td>Write specifications&lt;br&gt;Develop commissioning plan&lt;br&gt;Design review (indicate # of review cycles)&lt;br&gt;Develop sequences of operation (if not well-developed by mech or controls contractor)</td>
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<tr>
<td><strong>CONSTRUCTION PHASE</strong></td>
<td>Review submittals&lt;br&gt;Construction observation&lt;br&gt;Verification checks/prefunctional testing&lt;br&gt;Functional testing&lt;br&gt;Commissioning provider significantly involved in issue resolution&lt;br&gt;Oversee training&lt;br&gt;Review O&amp;M manuals&lt;br&gt;Develop systems manual/recommissioning manual&lt;br&gt;Perform trend analysis&lt;br&gt;Evaluate energy cost savings&lt;br&gt;Final report&lt;br&gt;Commissioning provider development of design intent</td>
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<tr>
<td><strong>O&amp;M TRANSITION PHASE</strong></td>
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Mission Critical Commissioning Levels

Mission Critical Acceptance Phase Details:
- Level 1 - Factory Acceptance Testing
- Level 2 - Component Start-Up
- Level 3 - Equipment Level Testing
- Level 4 - System Interface Level Testing
- Level 5 - Integrated System Level Testing
Levels of Commissioning

**Definition of Levels:**
Testing occurs in five progressive levels with the successful completion of the previous step being a prerequisite activity to moving on to the next level. The five levels of testing are as follows:

**EXAMPLE- Standby Power System**

**Level I- Factory Witness Testing**
- Level I testing includes developing/approving and witness tests of components or pre-assembled systems performed in the factory.
- FWT is done to prevent un-repairable defects (particularly in long lead items like generators) in components from reaching the job site.
- Certain components tests may not be performable in the field.

**Level II - Component Start Up**
- Level II typically includes field testing of: sensors, switchgear components, breakers, relays, transformers, etc.
- These testing and checkout activities are the standard construction and installation quality control and field testing using the specified codes and standard guidelines.
- This testing level will verify correct torque, grounding, insulation values, calibration and equipment controls and alarm points.
Level III – Equipment Testing

- Level III Start-up Testing typically includes: new diesel generator package and controls, new and existing paralleling switchgear modifications, new/modified substations, battery systems, fuel oil supply system modifications, BMS/power monitoring system modifications, fire protection and fire alarm systems modifications, and building envelope modifications.

- Typically load testing to nameplate ratings and thermal scanning will be performed during equipment start-ups.

- Instrumentation and controls checkout and BMS point to point and sequence of operation checkouts are also performed.
Levels of Commissioning - cont.

Level IV –System and Interface Level Testing

- Level IV testing typically includes verification that: substations are operating properly; the new generator heat run, generator step loading, generator alarms, shutdowns, and start-stop sequence controls are working and fuel supply are operating properly; the existing/modified paralleling switchgear is operating properly; the life safety systems such as fire protection and fire detection and alarm are functioning.
- Typically load testing and thermal scanning is performed during this test level.

Level V -Integrated System Level Testing

- Level V testing is the highest level of testing whereby the combined Facility and installed systems are operated as an Integrated Facility configured to simulate its design performances and operating conditions to the maximum extent possible.
- The Integrated Tests are the acceptance tests to demonstrate that the Facility has met the overall performance and full compliance with the Design Intent as specified in the Project Design Manual, Specifications and Drawings.
- Typically, simulation tests of an outage and other failure mode tests verify the operation of all systems working in unison and validate that the redundancy design requirements are met and that integrated electrical, mechanical, and control systems confirm proper operation while interaction occurs.
Summary

- Basic Approach is Similar
- Skill sets are different
- Window of commissioning may not occur during normal business hours
- You are not commissioning a building, you are commissioning a system closely tied into your client's business process
- Functionally – tying together building and electrical systems to ensure reliable operations per the Owner’s system requirements
Document the “As-Built” Facility

Documentation begins early

- Design Phase
  - Owner’s Project Requirements (OPR)
  - EOR’s Basis-of-Design (BOD)
  - CxA’s Commissioning Plan & Systems Operations & Maintenance Manuals (SOMMs)
    - Cx Plan is a “Living Document” describing “how”
    - Can form the basis of the Final Cx Report if properly organized, compiled & maintained throughout the project
    - SOMMs describe “what”
  - Ultimate goal is to deliver comprehensive SOMMs
Document the “As-Built” Facility

Documentation continues through construction

• Embellish the Commissioning Plan/Manual
• Include as much material as possible as the project progresses and organize as SOMMs
  ○ OPR
  ○ BOD
  ○ Submittals
  ○ Progress Reports
  ○ Shop Drawings and “Red-Lines”
  ○ Installation and O&M manuals
Document the “As-Built” Facility

Acceptance Test Phase

• Completed scripts provide “Baseline” performance, setup, & configuration data

• Collect reports for:
  o Startup & Checklists
  o Pre-Functional Tests
  o Functional Tests
  o Integrated Systems Tests

• Record actual values (vs. pass/fail)

• Use automated data collection technology (permanently installed + temporary)
Document the “As-Built” Facility

Acceptance Test Phase

• Example Startup & Checklists reports
  ○ Arc Flash, Fault Current, & Breaker Coordination
  ○ Meggering, Grounding, Primary Injection Test reports
  ○ Pressure & Leak tests, cleaning & flushing, & water quality
  ○ Expansion Tanks, Backflow Preventer Certs, etc.
  ○ Refrigerant Logs, Fuel Oil Tests
  ○ VFD Programming & setup values
Acceptance Test Phase

- Example Pre-Functional Test reports
  - Building Automation System (and other Monitoring & Controls) “point-by-point, end-to-end” tests
  - Alignment & balancing reports
  - Vibration analysis reports
  - Test, Adjust, & Balance (TAB) reports
  - Thermography (Infrared scan) during Load Banking (“Burn-In”)
  - Test equipment “safeties” and “trip” settings
Document the “As-Built” Facility

Acceptance Test Phase

• Example Functional Test reports
  ○ Performance trends using data recorders (BAS, SCADA, EPMS, PQM + temporary metering)
    - Stable operations (including efficiency verification)
    - Transient operations (including step-load responses)
    - IEEE Battery Testing
  ○ System-level Sequences-of-Operations
    - Normal operations
    - Normal switching operations
    - Failure scenarios (pumps, towers, chillers & thermal storage, gensets, UPSs, etc.)
Acceptance Test Phase

- Example Integrated Systems Test reports
  - Integrated System-level Sequences-of-Operations
    - Normal switching operations
      » Utility to Gensets (closed transitions)
      » Mechanical to Economizer cooling (and return)
    - Failure scenarios
      » Loss of off-site electric utility (pull-the-plug)
      » Loss of municipal water supply
Document the “As-Built” Facility

Final Cx Report and Systems Operations & Maintenance Manuals (SOMMs)

• The Final Cx Report describes the entire commissioning process as applied to the project

• SOMMs describe the “as-built” facility and infrastructure and are organized by system
  ○ Use a consistent format, organization, and content
  ○ Group information and systems in a logical manner (ex.: follow the CSI spec progression)
    - General site information and requirements
    - Trades (plumbing, mechanical, electrical, security, etc.)
Document the “As-Built” Facility

SOMMs Content (for each system)

- System description narrative
- Single-line and/or shop drawings
- Sequences-of-Operations
- Approved (final) Submittals
- Related completed PFT, FT, and IST reports
- Standard Operating Procedures (normal, maintenance, emergency & recovery)
- Installation and O&M manuals, parts lists, etc.
- Warranties and Service Level Agreements
O&M Staff Training is a Deliverable!

- Start with a Training Plan (part of the Cx Plan)
- Design a Training Curriculum based on site specific needs and requirements
  - Tailor the training to fit the O&M organization, duties, and responsibilities
    - Jack-of-all-Trades or Trade Specific?
    - O&M or Operations or Maintenance?
    - In-House or Out-Sourced?
- Use the SOMMs for training materials (so SOMMs must be completed early)
Start Training Early

- O&M staff can get valuable training during the construction and acceptance test phases
  - FWTs
  - Progress Inspections
  - Vendor provided, equipment specific training
  - Site-specific, systems-level training
    - PFTs, FTs, and ISTs
  - Progress from classroom (academics) to field (demonstration & hands-on)
- Goal is to have fully trained staff on “day-1”!
Train the Staff

Training is required over the life of the facility

- New hires and staff development
- Remedial training where performance justifies
- Continuous training (especially for infrequent and unusual scenarios)
- Facility upgrades, expansions, modifications
- So, training delivery should be “repeatable” and “editable”
  - Record, document, and update
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Thank You & Questions???

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