Commissioning Electrical Systems in Mission Critical Facilities

Port Authority of NY & NJ – World Trade Center (WTC) Transportation HUB
Social Security Administration- National Support Center

April 17, 2019

Presented By:
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Safety Moment

• Hearing Protection
  – Environment can reach over 100dB during generator full-load testing

• Flame Resistant Clothing
  – UPS door panel cannot close when the current transformers of a power quality meter are connected during full-load testing.

Source: OSHA.gov
Presentation Highlights

• Background of Two Projects
• Challenges at the WTC Transportation Hub
• Challenges at the SSA NSC Data Center
• Test Methods and Testing Process
• Take-Away Issues
Challenges and Opportunities Presented by Electrical Commissioning

- Verification and review of NETA Results
- Verifying component functionality
- Verifying function of electrical systems
- Intra-system & Inter-system functionality verification
- Interaction of energy supply and load
- Functionality of all systems during transition from Normal to Standby Power and back to Normal Power.
- Parallel testing events that can occur during electrical commissioning
World Trade Center (WTC) Transportation Hub
World Trade Center (WTC) Transportation Hub

• Known as the “Oculus”
• Center of an integrated network of underground pedestrian connections
• 800,000 square feet
• Connects visitors to
  – WTC Towers 1, 2, 3, and 4
  – 11 different NYC subway lines
  – PATH rail system
  – Brookfield Place
  – National September 11 Memorial & Museum
  – Battery Park City Ferry Terminal
World Trade Center (WTC) Transportation Hub
**Fundamentals**

- Equipment thoroughly cleaned
- Lock Out, Tag Out (LOTO)
- Integrity Tests
  - Visual
  - Mechanical
  - Electrical
    - Ground-Resistance
    - Insulation-Resistance
    - Over-Potential
    - Current Injection
Examples of Fundamentals
Uninterruptible Power Supply (UPS)

- The output of the ATS must be connected to the primary source input of the UPS, or the UPS load won't be protected with emergency power.
Kirk Key Interlock

- Incorrect installation will result in accidental outage of UPS downstream load

Move Kirk Key to 'UPS Output Isolation' (SW3)
Automatic Transfer Switch (ATS)

• During functional testing, confirm signals to the following systems
  – Paralleling Switchgear
  – Elevator Controllers
  – SCADA
  – Fire Alarm
Diesel Generator & Paralleling Switchgear

- Full-load testing of each generator per NFPA 110
- Paralleling Switchgear Integration
- Testing of system alarms and interlocks
Integrated System Testing (IST)

- Complexity requires logistical planning
- Communication is key
- Dry run of test ensures everyone’s understanding of their role and responsibilities
- Black Start (Pull the Plug) Test
  - Facility successfully operates on emergency power
  - Load Shedding of ATS units, based upon ATS priority level
  - Bus Optimization of Paralleling Switchgear
SSA NSC Project Background

• A Shovel Ready Project - Funded through ARRA

• Rural Site in Urbana, Maryland on 50 greenfield acres

• Three buildings commissioned:
  – Office Building
  – Data Center (main structure)
  – Security Building

• SSA is the Owner

• GSA managed the program

• 350,000 sf total facility size

• Jacobs performed CM and CxA
Project Background- SSA Project Drivers

- Replace an obsolete existing Data Center infrastructure
- Consolidate existing SSA facilities
- Exceed industry standard metrics for maintenance and operations costs
- Protect from cyber threats
- Handle growing demand on the network, (e.g. electronic hearings).
- Meet Federal Government mandate for increased energy efficiency
- Modernize physical security infrastructure
Day One Facts and Figures

- 52,000 sf of white floor space
- 4800 tons total chilled water capacity (N+2)
- White Space: 6MW electrical capacity (2N) expandable to 10MW installed standby power
- 20 minutes of Thermal Energy Storage
- Uptime Institute Tier III Certified
Electrical Commissioning: SSA NSC Data Center

- Focus on electrical commission of mission critical facilities using my experiences with the SSA NSC data center. What worked, what didn’t
- Discuss the integration and combined test with other disciplines
- Complexities of testing mission critical facilities
- Uptime Institute required testing (Tier III)
Communication

• Electrical Cx is not standalone and done in a vacuum

• The operation of the electrical systems need to be fully integrated with the operation of the mechanical systems to serve the critical areas of the facility

• 3 Cs of Mission Critical Cx: Communication, Coordination & Cooperation

• Early Involvement and Development of the Team
  • Electrical Contractor
  • Mechanical Contract
  • Construction Manager
  • Owner
Early Involvement

• Early engagement of the commissioning agent is necessary:
  • start of project’s concept design
  • design reviews and lessons learned to help with commissioning, aid in scheduling and be a future benefit for the owner.

• Coordination & Scheduling
  • Cx testing must be blended into the overall construction schedule, not just something that happens at the end. Traditionally the end date get later and later
  • Begin to embed Commissioning into the 1st schedule developed
  • Provide anticipated test durations to CM as soon as possible
  • Include setup and breakdown time is included for load banks
  • SSA also had the Uptime Verification testing to be scheduled after the commissioning
Design Reviews

- During resign reviews, make any recommendations to help facilitate the commissioning of the system.

- IR inspection ports to facilitate IR scanning during commissioning, and for future use but the owner for preventive maintenance.

- Work closely with the Mechanical CxA and see where electrical can facilitate the mechanical commissioning and reduce testing time.
Stand Alone Testing

• Generators, UPSs, ATSs and Switchgear should be tested individually to a point by simulating the operation of related equipment. This will confirm operation parameters, transient response and sequencing within that piece of equipment.

• Test Generators and UPSs with inductive/resistive load bank to verify operating parameters.

• Understand what the transient parameters are and test to them. Is it step load response of full single 100% step response.

• ISO 8528 is a good reference if there is no performance criteria.
Combined Testing

• It is OK to combine testing of multiple systems or pieces of equipment together
  • Create “Mini ISTs”
  • Verify operation of downstream equipment
  • One of the most overlooked items is the recovery of downstream equipment after a power transition.

• Paralleling gear represents a unique challenge
  • Factor Testing: You can do things with generator and load simulators that may not be advisable in real life
  • Paralleling gear should be tested with generators and a load bank. Load Banks sufficient to handle full capacity

• Pretest any test Uptime Institute will wish to witness as part of any FPT, “Mini IST”, or IST during Cx (if applicable)
Electrical Block Diagram – SSA Tier III
Load Bank Testing - FPT and IST

• Distributed load banks on the data floor – Simulates Actual operating conditions.
• This tests steady state and failover conditions both Mechanically and Electrically
• Scheduling setup and breakdown time must be anticipated.
• Allow additional time to step up and step down the individual load banks to desired settings during testing.
SSA - Load Bank Testing

• Portable load on the data center floor connected directly to the PDUs simulates actual power & heat load of Day 1 conditions up to full Day 2 buildout.

• Water-cooled load banks can be used to simulate the water-cooled loads on the data floor.

• A caution when connecting air cooled load banks control power.

• Simulation of PUE (Power Usage Effectiveness) at various load profiles.
Full Hot Aisle Containment

• SSA Data center floor design used modified Hot Aisle Containment:
  • Racks vented directly to the hot aisle
  • Rack vented to Ceiling - Chimney design
  • Water cooled racks

• Creativity – needed for locating Load Banks.
Load Bank Set Up Hot Aisle Containment.

- Racks were not installed at the time of testing
- Fully contained hot aisles were simulated
Load Bank Set – Chimney Style Racks
**IST Challenges**

- 100 separate IST tests, (+68 Uptime), ranging from thermal load change, full verification of thermal storage to electrical and mechanical failovers.

- IST tasks:
  - Set up and breakdown of load banks-Load Bank adjustment and settings
  - Thermal plant & thermal storage commissioning
  - Complete electrical redundancy
  - 24 hour burn in
  - Uptime Pre-Testing
  - Repeat of tests as required

- It is important to have all personal available so quick action can be taken when issues arise.
## Load Bank Graphic Developed for IST Testing

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<th>Condensing Water</th>
<th>Chill Water</th>
<th>Air Handling</th>
<th>Heat Recovery System</th>
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### Table: Voltage, Current, Power

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**Total PDTM Output:** 4623.97 kW

**RPP Total Output:** 500.93 kW
IST Challenges - Data Gathering

- Look for opportunities to develop custom graphic IST pages with pertinent data within the BAS or PCS control system to aid in the gathering of test data so you don’t have to scroll thru pages of screens or have multiple personal stationed around the facility.

- Verifying expected PUE was a requirement, and a real time graphic was developed for doing that.
Specific Graphic in the PCS To Verify PUE
## Integrated Systems Test “Show Stoppers” List

<table>
<thead>
<tr>
<th>Column</th>
<th>Data</th>
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<td>Test Function or Item</td>
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### Table Data

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<th>Implications</th>
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<th>Mode</th>
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### Status

- **CLOSED**
- **OPEN**
Conclusions:

- Commissioning Mission Critical facilities entails significant up-front planning.
  - Schedules must be realized and blended together
  - Must engage professionals in the conceptual phase
  - Goals must be realistic, balancing cost vs. performance decisions

- Teamwork & Integration
  - CM & CxA need to work closely so that projects delays are minimized, issues resolved, and the overall schedule is adhered to

- Testing was done with all team onboard & available
  - Issues could be quickly addressed, and testing continue
Thank You

Questions?
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