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Commissioning Critical Electrical Infrastructure – Real World Objectives

by

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Abstract

This paper discusses commissioning of critical electrical systems such as UPS/CPS systems, ATS/Genset system, battery systems, critical switchgear, and more. Sample testing criteria are given. Typical equipment failure rates are discussed along with commissioning objectives & mitigation measures. The benefits of independent (3rd party) commissioning are presented. The author presents real world case histories.

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Why Commission?

A leading data center availability/uptime group states that 70% to 80% of the system outages for data centers and similar critical environments are based on human error. Without question, comprehensive commissioning, along with proper maintenance and personnel training can minimize outages based on human error.

Good commissioning accomplishes several things. Most obviously, people assume that commissioning will ensure that equipment purchased will perform to stated specifications. This is true, but the commissioning process goes beyond that if done correctly. When commissioning agents are brought into the project early enough, the first mission is to ensure that Design & construction documents reflect the client's performance expectations. Next, we make sure that the contractor has properly interpreted the construction documents to meet owner's expectations. We then address long term performance assurance to match the projected life of the facility. Finally, we ensure that facility engineers & operators are capable of properly operating & maintaining the commissioned infrastructure.

There are many papers written covering the basic premises of commissioning critical facilities infrastructure. We will not review those basics here beyond what was said above. But it is worth a few moments to discuss why critical electrical commissioning is particularly important to Tier II, II and IV facilities such as Data Centers. While most mechanical system commissioning involves HVAC systems with a major priority being confirmation of their energy usage, electrical systems in a critical facility carry an even larger responsibility and risk. A split second loss of electrical power to mainframe or server computer systems means immediate system down, with full recovery times often taking hours or even days. Because of complexity in number and coordination of interrupting devices, power & control systems, and interfaces & relays, an outage might easily occur anywhere in the system if things are not checked carefully. If just one small area of installation or design is missed and commissioning does not pick this up in test, millions of dollars of critical electrical facilities infrastructure may be compromised.

Independent Commissioning Overview

Some organizations argue that commissioning is more cost-effective if done by the groups installing the equipment. There may be parts of this which are true if up-front costs are all that are considered. But the true cost of equipment commissioning is more typically found in the avoidance (or lack of avoidance) of critical systems failures months or years after installation. While installers may know their equipment very well, there is an undeniable bias towards getting any/all tests of such equipment approved as project completion and final payment approaches. Independent commissioning review eliminates this natural bias. Ideally, the commissioning agent may not even report to the same manager at the same tier as the equipment supplier. But even when this is true, an independent commissioning agent owes nothing to, and expects nothing from, the equipment provider.

Just as importantly, while one factory or installer group may know <u>their</u> system well, they may or may not know anything about the critical system(s) interfacing their equipment. The independent commissioning agent looks at the entire critical facility electrical system holistically, filling the gaps left from one vendor to another. An example of this might be commissioning a UPS system with a standby generator system. Genset techs are somewhat familiar with problems caused by poor UPS input harmonic distortion, excessive capacitance, or poor PF. UPS techs are somewhat familiar with genset alternator inrush or sub-transient reactance limitations, and/or governor & control-side issues. But neither will ever assume responsibility of proper operation of the integrated system. The role of the properly trained independent commissioning agent is to assume that responsibility.

Failure Rates

Commissioning time and effort should generally be proportionate to both the expected failure rate and criticality of the equipment being commissioned. So the more critical the equipment and the higher the potential failure rate of the

equipment class, the more time spent planning and executing the commissioning plan. By example, a newly installed 500 KVA transformer feeding non-essential loads may be 10 times larger than a 50 KVA UPS feeding more critical loads, yet get much less of the total commissioning budget. On the other hand, if a site has a 50 KVA UPS and a 500 KVA UPS, both feeding equally critical loads, the 500 KVA commissioning may be properly more comprehensive (expensive) since there are 10 times more of these critical loads served. Ideally, all critical infrastructure would get equally comprehensive commissioning programs. But in the real world of budget cutting and quarterly results, things aren't always ideal.

There are times when an experienced commissioning agent can help an owner cut budget while maintaining rigorous commissioning. We have seen countless cases where the entire slate of factory tests has been duplicated on site at great expense. Sometimes, factory tests should be repeated on site. That might be the case where shipping damage or vibration could be a factor, factory tests were not witnessed or were done improperly, or other issues are at play. It is important to retain an independent commissioning agent with enough experience in the products & technologies involved to know which tests can be performed just once (at factory), and which need to be performed on site.

Cases

Tell-Tale IR

MC West was supervising the commissioning of a key rental CPS system for a major client. This system was trailer-mounted and had seen service nationally on lease from its owner, a leading genset & UPS provider. The system was supposed to have been completely checked out before shipment to the site. During the commissioning process, we recorded clear temperature rise on (only) one of the 3 phase lug-to-bus bar connections under load. We knew the history of this module, which included over two years of service traveling over bumpy roads without air shocks, and intermittent on again, off again power-ups for various clients, we decided to order a re-torque of all power connections regardless of IR signature. As it happens, 4 of the connections checked were not even close to spec, with one being just hand-tight (we actually loosened it by hand).

Ran Great for a While

Here, we were re-commissioning a single engine genset & (3) ATS system for a client. The client's utility history indicated only short term outages (under an hour) over the eight year period it had records for. But we recommended a minimum of a 12 hour full load test for this client for two reasons. First, the site had grown significantly in load criticality over the past year, and second, the genset back-up was non-redundant. During the first 30 minutes of system testing, we picked up a

few small issues (inrush/load distribution & staging) but nothing major. However, while running at full load for just over nine hours, not one but two separate problems surfaced. A leak had developed in one of the coolant hoses, and an idler arm was beginning to show signs of bearing failure. The idler and all hoses were replaced, the system retested perfectly.

At another much less critical site several years ago, an entirely different problem occurred, with the same ultimate result: genset failure. In this case, the genset was even tested for long periods without failure. However, actual outages never lasted longer than an hour. But one outage finally occurred which lasted over 12 hours, and when it did, the genset quit. Turned out the main to belly tank transfer pump was on unprotected house power, not genset power. A low fuel alarm was lit but not observed in time. The issue didn't surface during the long term genset test because the circuit feeding the transfer pump was never lost. Lesson: When commissioning, do everything you can to simulate real world conditions!

It worked fine with the other guy

At one very large and complex site we managed critical construction & testing for, the client had an existing system-plus-system, multi-module parallel UPS they were expanding. This UPS configuration featured dual input and output CB's for each of the UPS modules as well as a system hot tie and various ways of effecting partial and full bypasses. Since the system was well over ten years old, there were severe limitations to the automation of key operational sequences. During one set of tests designed to move the system from "A" side to "B" side, the lead facilities engineer performed the operation flawlessly, hardly looking at the complex instructions. However, when we recommended the off-shift lead do the same operation, an entirely different result occurred. As it happened, this individual did not get to operate the system very often (shall we say ever?), and was clearly afraid of manipulating the breakers when put to the test. Since we were well-armed with pre-approved scripts and stand-by experienced operators, no outage occurred, but lessons were certainly learned pertaining to personnel training and user-friendly written procedures.

Inside or Outside

MC West was recently involved in the commissioning of a new 6,500 sq. ft. data center utilizing high density blade servers. The infrastructure the client was primarily concerned with was a multi-module UPS they purchased used from another party. Part of the commissioning was a series of full load and overload tests requiring load bank. Rather than using the standard single large rollup load bank outside with temporary cabling, we suggested mimicking the soon-to-arrive high density racks by placing a series of "suitcase" load banks on the data center floor itself. In doing so, we were able to check capacity and leak-tightness of the CRACs during a relatively real world sustained heat run. We were also able to check flow modeling to some extent and tweak CRAC vane and perf tile issues.

Wasn't my "Fault"

This client was a large Midwestern Tier III facility with all the right stuff. 2N+1 UPS, dual source PDU's, N+2 parallel diesel generation system, you name it. In this case, MC West was not acting as the commissioning agent, but rather the Construction Project Manager. Still, we had an upfront seat to most of the commissioning. As it so often happens, some of the commissioning work was presumed to have been subcontracted out to key vendors approved by, and working for the site as part of their normal equipment maintenance. In this case, the complex parallel genset system, and its integral output distribution board, were maintained and tested by others. So there were assumptions that this section of the critical electrical system was in good shape. When it came time to do some key "pull-the-plug" tests of the UPS and PDU distribution, it was decided that this test be done on genset back-up, simulating real world conditions. One test involved closing a tie breaker, looping two sources which were synced, but several hundred feet apart. During the actual closing of this breaker, an unexpected but relatively small current was produced. Unfortunately, the current was large enough to trip the 3000A main genset output CB on GF and dump the site. As it turned out, the sub-contractor maintaining the genset board had replaced this breaker during a prior visit but left the LSIG trips in the minimum factory settings. So the breaker coordination work done prior to that, and the comfort level it presumably provided, was now long gone. The good news was that the event occurred during a low criticality weekend window. But it shouldn't have occurred at all if the breaker was checked and/or commissioned before the test.

Bad Batteries

We were brought in to help a client figure out why their UPS batteries had gone bad after less than a year. High ripple current and/or excessive short cycling was suspected. When we arrived on site, we asked if we could review the test results which indicted the "bad" batteries. The test docs showed an unusual scatter of impedance values, given the age of the batteries. After interviewing the facility engineer who did the testing, we discovered that since it was difficult for him to test the impedance of the cell directly through the post(s), this engineer took his measurements through the connector hardware. The range of variation caused us to question either the torque values on the connectors, the quality of the connector to post interface, or a possible manufacturing defect in the batteries. The torque values checked out as generally OK, but there was high impedance from connector to post. As it turned out, when the batteries were installed, someone used a "new & improved" battery post coating they got somewhere which was obviously not designed for contact interface. After the coating was removed, posts cleaned & retorqued, and everything re-tested, the batteries proved to be fine.

Summary
Proper commissioning and re-commissioning can make all the difference in critical electrical facilities infrastructure. System uptime, equipment warranties, contractor relations, loss of use, personnel safety, many areas are directly affected when systems do not perform as expected. To ensure the most comprehensive and cost-effective commissioning for critical facilities equipment, make sure your commissioning agent is experienced in the technologies you are considering. Finally, ensure that the agent is truly independent.

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The Author
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