



Electrical Cx for Mission Critical Projects

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AIA Quality Assurance



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Course Description

Commissioning mission-critical electrical systems can be challenging, especially given the limited formal training. To ensure the safe startup and thorough testing of electrical equipment, this webinar aims to introduce participants to the fundamentals of mission-critical electrical commissioning. This session will compare the Level 0-6 testing process and the BCxA Best Practices. Attendees will gain insights into various topics, including:

- Medium and low voltage designs
- Redundancy
- Short Circuit Coordination Studies
- ARC Flash labeling
- Foreign Object and Debris (FOD) management
- Best practices for tamper sealing and energization processes

We will detail the necessary procedures, including:

- Method of Procedures (MOPs)
- Lockout/Tagout (LOTO) processes
- Required safety gear
- ARC Flash boundaries and limited approach
- Proper personal protective equipment (PPE)
- Paperwork and pre-testing requirements

Additionally, the webinar will cover how to partially energize the controls section of electrical equipment to begin the verification process and interface with Energy and Power Management Systems (EPMS). Key topics include NETA testing, Megger, continuity documentation, and ensuring equipment cleanliness before energizing. Furthermore, we will discuss the coordination required for owner-furnished/contractor-installed equipment (OFCI) to effectively manage the scheduling and duration of tasks within the project timeline. Finally, we will explore what occurs once Level 3 (L3) is completed and ready for Level 4 (L4) Functional Testing (component testing) and Level 5 (L5) Integrated Testing (system-level testing). This includes reviewing load bank plans, arrangements, and support necessary for verifying design loads for both mechanical and electrical systems.

Learning Objectives

Discuss safety

Identify and define the Levels of Cx

Review Systems commonly found in Mission Critical (Data Center) projects

Ensure sequencing of the Cx process is correct

Clarify what is needed to successfully verify installation, start-up, checkout and Cx of electrical systems

Identify team members

Review Foreign Object Debris (FOD) Inspection

Highlight best practices

- Documentation
- Planning
- Schedule

Review lessons learned

Safety

Pre-planning

- Electrical pre-meeting, pre-energization meetings, Daily Hazard Analysis, Method of Procedure

Verifying workers possess the appropriate level of training and are current with certifications/credentials.

- NFPA-70E ARC Flash training and ARC Flash awareness training

Verification all required testing has been completed

- Insulation Resistance Testing (Meggering)
- Continuity Testing (Point to Point)
- Torque verification
- Required NETA testing, protection relays programmed, PQM's tested
- ARC Flash Analysis
- Short Circuit Coordination Study (SCCS)

Quality inspections completed, checklists

Thorough Foreign Object and Debris (FOD) Inspections

Tamper Seals

Most Mission Critical projects have a ladders last policy

Lock out, Tag out (LOTO)

Implement safe work permits; Energized Electrical Work, auditing of safe work practices and procedures

Safety – ARC Flash Boundary

Restricted Approach Boundary

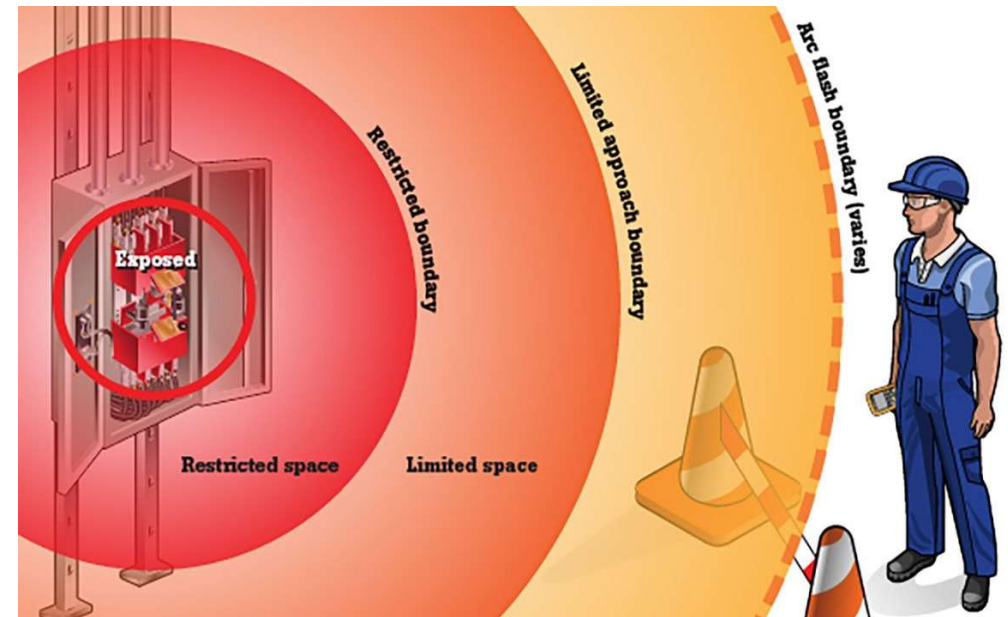
- Entered only by qualified persons. Required to use shock protection techniques and equipment
- Must have completed the required training

Limited Approach Boundary

- Entered only by qualified persons or unqualified persons escorted by qualified person. Must wear the appropriate PPE

Arc Flash Boundary

- Minimum “safe” distance from exposed energized conductors/circuit parts that has potential for arc fault.
- If necessary for an employee to enter the Arc Flash Boundary, then the proper arc-rated PPE must be donned.



Safety – ARC Flash Label

1

Danger or Warning header.

A common guideline is to use the "Danger" header when the voltage is over 600 or when the incident energy is over 40 cal/cm². If it is less than this threshold, an orange "Warning" header is typically used.

2

"Incident Energy at" is the corresponding working distance.

The Institute of Electrical and Electronics Engineers (IEEE) defines this as, "the dimension between the possible arc point and the head and body of the worker positioned in place to perform the assigned task."

3

"Min. Arc Rating" is the incident energy.

A measurement in calories/cm² or Joules/cm² of thermal energy at a working distance from an arc fault.

4

Arc Flash Boundary.

This is the shortest distance at which a person working at the time of an arc-flash may receive permanent injury (the onset of a second degree burn or worse) if not properly protected by flame-resistant (FR) clothing.

5

Personal Protective Equipment (PPE).

Each hazard risk category requires a different level of protection. Categories range from 1 to 4. Category "0" was removed in the [NFPA 70E 2015 Changes](#).

6

"Limited Approach" and "Restricted Approach" fields are related Shock Hazard Approach Boundaries.

These boundaries are defined in more detail in our [Arc Flash Workplace Safety Guide](#). The "prohibited approach" boundary was removed in the 2015 [NFPA 70E](#) edition.

7

"Shock Risk When Cover is Removed".

The voltage of the equipment.

1 **WARNING**

**Arc Flash and Shock Hazard
Appropriate PPE Required**

FLASH PROTECTION		SHOCK PROTECTION	
Incident Energy at:	18 in	Shock Risk When Cover is Removed	480 VAC
Min. Arc Rating:	0.45 cal/cm²	Limited Approach	42 in
Arc Flash Boundary:	10 in	Restricted Approach	12 in
Glove Class:	00	Bus Name:	
PPE: Shirt & pants or coveralls, Nonmelting (ASTM F1506) or Untreated Fiber) + hard hat + safety glasses + hearing protection		PNL_P-5	
		Prot Dev: 100/3 BS-18 LAB PNL	

2 **3** **4** **5** **6** **7**

Safety - PPE

Cx Providers must be qualified to complete the tasks, follow site safety requirements and wear the proper PPE while completing testing and verification of electrical systems.

PPE CATEGORY 1	PPE CATEGORY 2	PPE CATEGORY 3	PPE CATEGORY 4
Minimum Arc Rating of 4 cal/cm² Arc Rated Clothing: • AR long-sleeve shirt and pants, or AR coverall • AR face shield, or AR flash suit hood • AR jacket, parka, rainwear, or hard hat liner (as needed) Protective Equipment: • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Heavy-duty leather gloves • Leather footwear (as needed) 	Minimum Arc Rating of 8 cal/cm² Arc Rated Clothing: • AR long-sleeve shirt and pants, or AR coverall • AR flash suit hood, or AR face shield and AR balaclava • AR jacket, parka, rainwear, or hard hat liner (as needed) Protective Equipment: • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Heavy-duty leather gloves • Leather footwear 	Minimum Arc Rating of 25 cal/cm² Arc Rated Clothing: • As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants • AR flash suit hood • AR gloves • AR jacket, parka, rainwear, or hard hat liner (as needed) Protective Equipment: • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Leather footwear (as needed) 	Minimum Arc Rating of 40 cal/cm² Arc Rated Clothing: • As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants • AR flash suit hood • AR gloves • AR jacket, parka, rainwear, or hard hat liner (as needed) Protective Equipment: • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Leather footwear (as needed) 

Safety - Energization

Develop a detailed Method of Procedure (MOP) for a step-by-step instruction for energizing equipment

- Includes a backout plan
- Reviewed by all parties affected by the work
- Best practice for first time energization
- Approved by the Energy Marshal
- MOP's for work that involves a change

Tamper Seals, Signage and a Controlled Access Zone

- Posting updated live one-line diagrams for energized equipment in the electrical room
- Only the person doing the switching and a safety/recovery person in the zone
- **"Energized Electrical Gear"** signage in English and Spanish on energized equipment
- Use of a remote actuator
- Danger tape/barricade area
- Clean and secure/access controlled electrical rooms



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Data Center Tiers

Tier I: Basic Capacity

- Offers fundamental capacity with no redundancy.
- Prone to potential downtime risks due to single points of failure.
- Suitable for small businesses or non-critical applications.

Tier II: Redundant Site Infrastructure

- Provides redundant components, minimizing the risk of downtime.
- Scheduled maintenance activities might still cause disruptions.

Tier III: Concurrently Maintainable

- Designed to allow maintenance and upgrades without disrupting ongoing operations.
- Equipped with redundant components and multiple distribution paths.
- Ideal for businesses seeking increased uptime for critical applications.

Tier IV: Fault-Tolerant Infrastructure

- Offers exceptional fault tolerance.
- Features fully redundant systems, ensuring uninterrupted operation even in the face of a single point of failure.
- Best suited for mission-critical operations and organizations demanding near-zero downtime.

DETAILS	TIER I [1]	TIER II [2]	TIER III [3]	TIER IV [4]
	Basic Capacity	Redundant Site Infrastructure	Concurrently Maintainable	Fault Tolerant
Uptime Requirement	99.671%	99.741%	99.982%	99.995%
Downtime Allowance	29 hours per year	22 hours per year	1.6 hours per year	26.3 minutes per year

Types of Data Centers

Enterprise / Hyperscale (Google, Microsoft, META, aws)

- A purpose-built facility for a single user that is typically operated by that user.
 - All have a robust Quality Process and Commissioning Plan

Core and Shell with Tenant Fit-out

- Spec built, leased out space which allows tenant to provide equipment and operations.
 - Many have a basic Quality and Commissioning process and rely on the tenants' specific plans for ensuring proper install and operation

Colocation (COLO)

- Tenants can be located together. Connections between customers is the selling point. Turn-key facility operated and maintained by landlord. Scalable security depending on tenants needs.
 - Quality and Commissioning process vary greatly. Many are in the process of further developing and refining their Quality and Commissioning process.
 - Many have openings or have recently hired Quality and Commissioning experienced staff.

Some larger Data Center developers are;

QTS, NTT, Stream, Aligned, T5, Vantage, Equinix, CyrusOne, Digital Realty, CoreSite, Iron Mountain, cologix, Oracle

New developers are entering the market at a breakneck speed.

Team Members

- Owner
- Owner's Rep. (Construction Manager)
- Facilities Management
- Engineer of Record
- Architect of Record
- BAS (BMS) / EPMS Vendor
- OFCI Equipment Vendor
- 3rd Party Cx Provider
- Owners in-house Cx Engineer

Trades (GC, EC, MC, BAS, TAB)

- QA/QC
- Energy Marshal
- Superintendents
- Operations (PM's/PE's)
- Cx Manager / Cx Coordinator
- Safety
- Owner Furnished Contractor Installed (OFCI) Manager

Equipment

Electrical

- MV/LV Switchgear
- MV/LV Transformers
- Generators
- UPS Systems
- Panelboards
- Switchboards
- Automatic Transfer Switch (ATS)
- Static Transfer Switch (STS)
- PDU/RPP/PDC
- Busway / Busduct

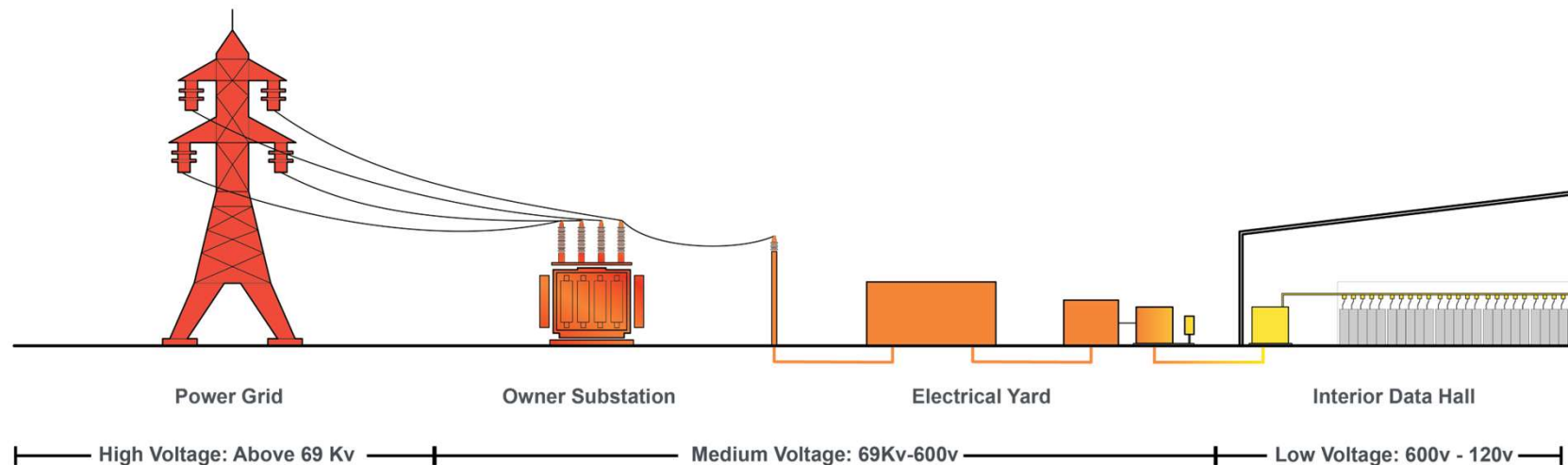
Mechanical

- Chillers
- Cooling Towers
- Air Cooled Condensers
- Industrial Water
- CRAC's / CRAH's
- Humidifiers
- Dehumidifiers
- Exhaust Fans
- Split Systems

Extra Low Voltage

- Main Distribution Frame (MDF)
- Intermediate Distribution Frame (IDF)
- Meet-Me Room (MMR)
- Networking
- BMS/BAS
- EPMS (PMS)
- Fire Alarm / VESDA
- Intrusion
- Card Access / CCTV
- Racking
- Racks

Utility / Power Design



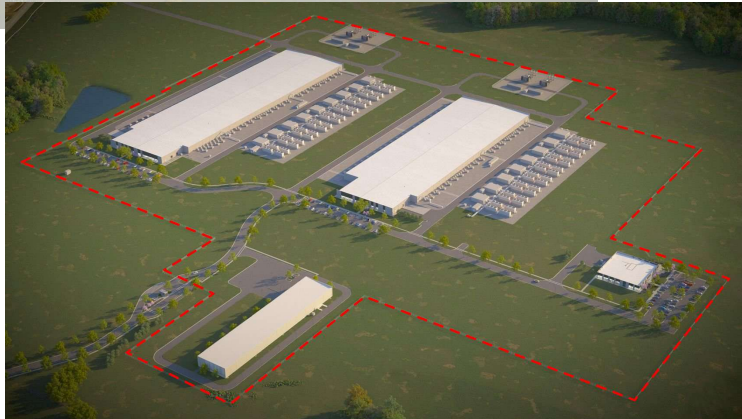
Most data centers operate at 35Kv
Typically there are redundant Substation feeds (either a different transformer or from a different substation).

Design

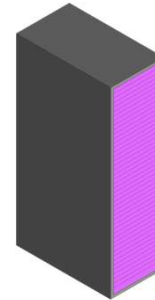


Building: 80 MW

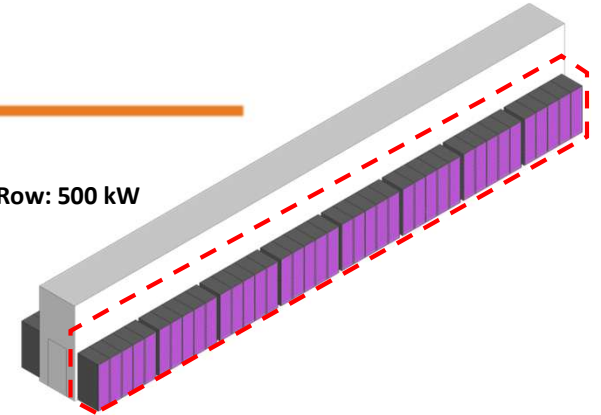
Campus: 160 MW



Rack: 12.5 kW



Row: 500 kW

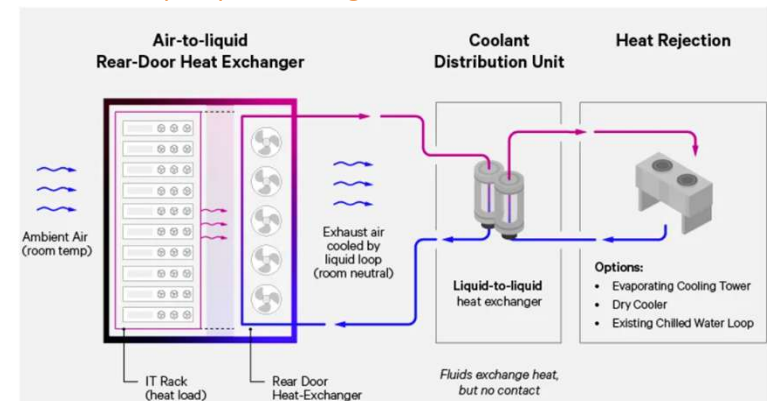


Average rack density is currently 14-15 kW

- Air Cooling is adequate

Artificial Intelligence (AI), Machine Learning (ML), High Performance Computing (HPC) demands up to 300+ kW

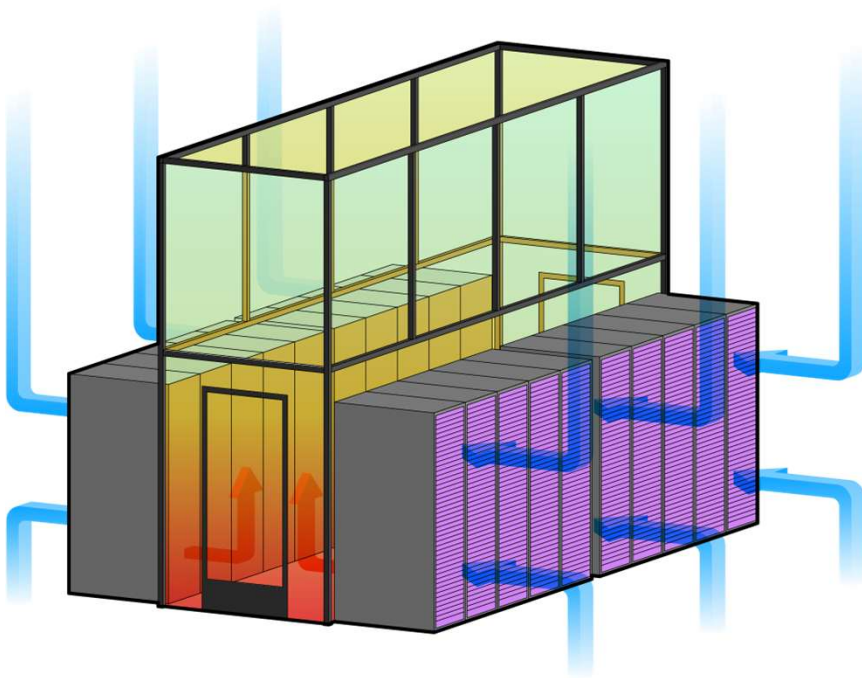
- Direct to chip, liquid cooling



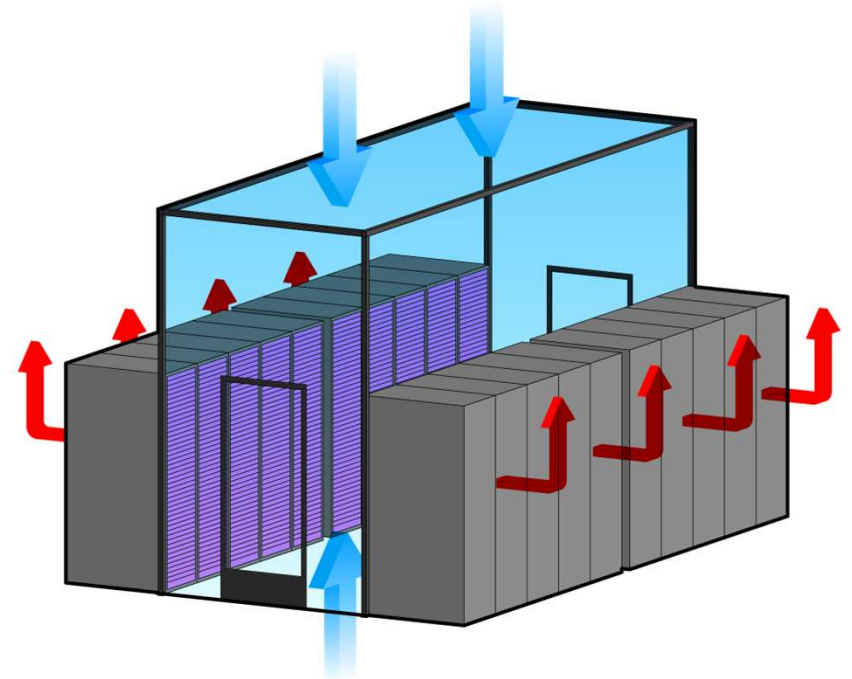
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Design - Containment



Hot Aisle Containment (HAC)



Cold Aisle Containment

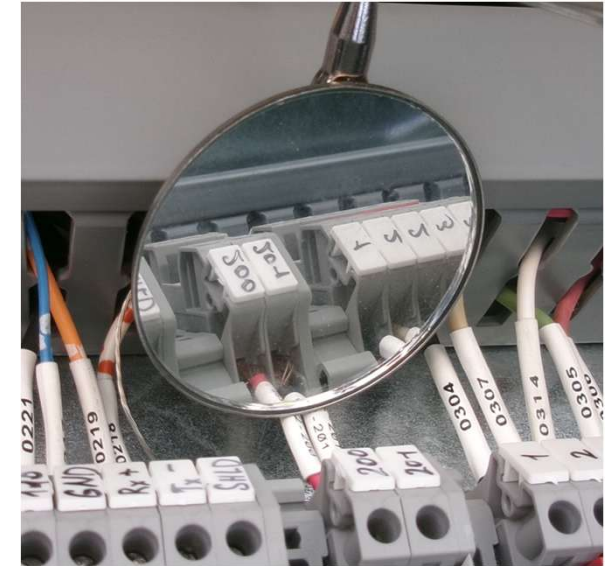
Foreign Object Debris (FOD)



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- Verify Field Torque marks, suggest 10% sampling
- Thorough inspection using mirrors, borescope
- Wire tug test
- Ensure labels are installed and correct

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Levels of Cx vs. BCxA Best Practices

- **LEVEL 0** | Design and Planning
 - **LEVEL 1** | Factory Testing
 - **LEVEL 2** | Component Delivery, Installation, Pre-Start-up
 - **LEVEL 3** | System Start-up
 - **LEVEL 4** | Functional Testing
 - **LEVEL 5** | Integrated System Testing (IST)
 - **LEVEL 6** | Closeout, Turnover, Handover
- **PRE-DESIGN**
 - Owner selects Cx Provider, OPR is developed, scope is defined, incorporate Cx into budget and schedule, develop Cx Plan
 - **DESIGN PHASE**
 - Cx Process confirms design documentation is consistent and meets the OPR, Cx spec development, design reviews
 - **CONSTRUCTION PHASE**
 - Update Cx Plan, OPR, BOD, integrate Cx schedule with construction schedule, review submittals, controls integration coordination, develop checklists, maintain issues log, Cx meetings, site visits, development Functional Tests, Functional Testing, review turnover documentation, Cx Report, verify training
 - **OCCUPANCY & OPERATIONS PHASE**
 - Timely addressing and tracking of open issues, conduct and verify O&M training, seasonal and deferred testing, optimize systems, check-ins with O&M staff, Final Cx report, develop PM Plan.

Level 0 Design and Planning

- Establish the Owner's Project Requirements (OPR).
- Develop the Basis of Design (BOD).
- Create a Commissioning Plan.
- Conduct design reviews and define acceptance criteria.
- Align all stake holders early in process.
- Clarify requirements for turning over the coordination study Native files.
- Identify the Cx software that will be used.
- Clarify options for safer testing, i.e. IR inspection windows.
- Plan for storing and delivering equipment, define storage criteria.

Level 0 Lessons Learned and Sequencing Tips

- Minimize Scope Gap.
- Early turn-over spaces requirements.
- Ensure clear testing support.
- Design guidelines for client are often never trued up, review previous build RFI's.
- Clarify who provides fuel.
- Identify who provides loadbanks, Power Quality Meters.
- OFCI vendor submittal reviews.
- Best practice for providing gear that requires IR scanning to come with IR windows to allow for safe infrared scanning of gear.
- Ensure doors are designed to allow for rack clearance.
- Ensure pathway to data hall has ceilings designed higher than height of the rack and pathways that don't have obstructions lower than the height of the racks.
- Clarify filter replacement and/or turnover of spare filters.
- OPR's and BOD's are often not provided.
- Cx Provider is usually not onboard until well into construction.

Level 1 Factory Witness Test (FWT)

- Equipment is tested at manufacturer's facility before it ships.
- Ensures components meet design specs and operate correctly in a controlled environment.
- Common for generators, UPS systems, switchgear and chillers.
- Common for First of Kind designs.
- Often the manufacturer doesn't have to adhere to specification requirements like the trades do.
 - Torque marking
 - Labeling

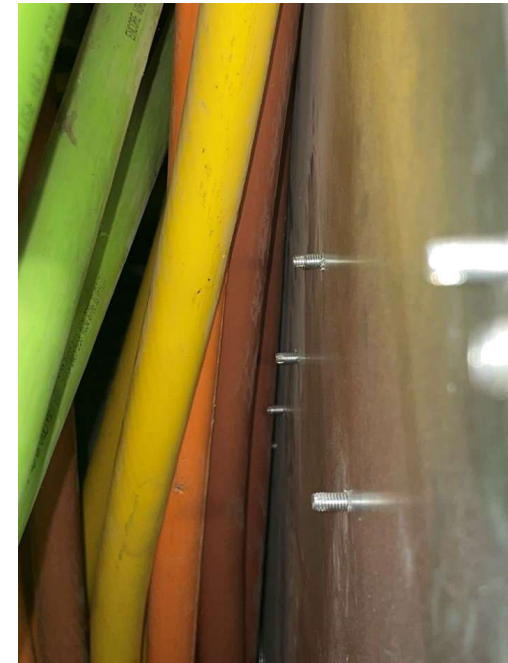
Level 1 Lessons Learned and Sequencing Tips

- Identify functional issues in a controlled environment
- Ensuring first of kind equipment is vetted prior to production runs for the whole project
- Having factory tech and design support to vet any issues encountered
- Ensuring that project requirements and specifications are available during the test
- Providing a final report of the testing, activity, include performance data and photos
- Identifying equipment connection / entry points



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Level 2 Component Delivery, Installation, & Prestart-up

- Confirms delivery, installation quality, and basic configuration on site.
- Includes pre-functional checklists, nameplate verification, and safety inspections.
- Verifies the equipment is installed per design before energizing.
- Verify factory wiring and assembly.
- Ensure that equipment is installed per manufacturers instructions.

Level 2 Lessons Learned and Sequencing Tips

- Underground coordination early as possible.
- Specifications and Drawing reviews early = Submittals match Equip delivered, model, type, breaker counts/sizing, etc.
- MV terminations done by certified installers.
- Capture Calibration certificates for tools being used.
- Temp power on early to the EPMS, BMS panels, Switchgear.
- Proper labeling of feeders, Mech equipment and Electrical gear.
- Early turnover rooms coordination for fiber entry, security, MDF, IDF, MMR, etc.
- Tenant Fit Out (TFO) scope reviews.
- Cx micro schedule alignment with P6 construction schedule/milestones.
- Vendors not required to match the same specifications as trades.
- Cx Provider starts L2/L3 verification team (often a mech and elec resource).
- Develop a loadbank plan, and secure training on loadbank operation, ensure there is a way to dissipate heat (and staying clear of fire sprinkler heads, confirm heat detector rating).
- After GEN's are set, tank pressure test, set Exhaust, complete L3, integrate into EPMS, Cx Provider to witness fueling.
- Heaters inside gear energized and ensure doors are shut during lower temps.
- Storing gear especially batteries per vendor requirements.



Level 2 Lessons Learned and Sequencing Tips

- Verify placement location of stickers and type (UV protected if outdoors).
- NETA Testing, requirements, tracking sheet.
- Calibration certificates on file.
- Testing documents requirements.
- Protection Relay settings.
- Cable testing, PQM testing.
- Primary/Secondary Injection Testing.
- DLRO / Megger / VLF testing (MV Cables).
- Failed testing generates an Observation/Issue for tracking.
- Post one lines in electrical room and update based on energization.
- Submittal for phenolic labels.
- GEN run logs and reporting.
- Use crimpers and dies from same manufacturer.
- Hardware management plan / ship loose items (trolleys, kirk-keys).

NETA

4-POLE LOW-VOLTAGE CIRCUIT BREAKER

CUSTOMER _____ PAGE _____
 ADDRESS _____ JOB # _____
 USER _____ CMMS # _____
 DATE 12/20/2024 TEMPERATURE 70 °F 21 °C HUMIDITY 50 % EQPT. LOCATION _____ Indoors
 PLANT _____ AREA/BUILDING _____ SUBSTATION _____ Circuit Breakers
 CIRCUIT ID _____ MCBU _____ TEST STATUS _____ Fail

MANUFACTURER: ABB INTERRUPTING RATING: 80kA Operation: ☒ E.O. ☐ M.O.
 BREAKER TYPE: SACE 60 2H-A1 TRIP UNIT TYPE: EXIP LBSI MOUNTING: ☒ D.O. ☐ B.I.
 BREAKER CAT. NO.: NL TRIP UNIT CATALOG NO.: N/A ZONE INTLK: ☒ YES ☐ NO
 FRAME SIZE AMPS: 4000A RTNG PLUG CAT. NO / CT: N/A THERMAL MEMORY: ☐ ON ☒ OFF ☐ NA
 SERIAL NUMBER: _____ CHARGE MOTOR VOLTAGE: 120-130V AC/DC

Visual & Mechanical Inspection Sat ☒ Unsat ☐ Note No.: _____ Visual & Mechanical Inspection Sat ☒ Unsat ☐ Note No.: _____
 RACKING DEVICES ☒ ☐ ☐ ARC CHUTES ☒ ☐ ☐
 CONTACT FINGERS ☒ ☐ ☐ AUXILIARY DEVICES ☒ ☐ ☐
 MAIN AND ARCING CONTACTS ☒ ☐ ☐ GROUND CONNECTION ☒ ☐ ☐

SETTINGS AS FOUND				SETTINGS AS LEFT			
	Setting	DELAY	IT		Setting	DELAY	IT
LONG TIME	5	3	ON	LONG TIME	5	3	ON
SHORT TIME	2	.4	OUT	SHORT TIME	2	4	OUT
INSTANTANEOUS	4	FIXED	-	INSTANTANEOUS	4	FIXED	-
Ground	2	.4	OUT	Ground	2	4	OUT

TRIP CURVE NO. Phase: 70C1034 / 70C1043 Ground: N/A

FUNCTION	RATED AMPERES	MULTIPLIER	TOLERANCE	POLE 1 (M1) (P1-P2P3P4)		POLE 2 (M2) (P2-P1P3P4)		POLE 3 (M3) (P3-P1P2P4)		POLE 4 (M4) (P4-P1P2P3)	
				AS FOUND	AS LEFT	AS FOUND	AS LEFT	AS FOUND	AS LEFT	AS FOUND	AS LEFT
LONG TIME	2000	300 %	6000	2.7	3.3	2.989	2.989	3.051	3.051	3	3
LTPU	+ % 5	+ % 20	2000	2100	2400	2235	2235	2248	2248	2254	2254
SHORT TIME	8000	150 %	12000	.36	.44	.415	.415	.414	.414	.417	.417
STPU	- % 7	+ % 7	8000	7440	8560	7960	7960	8040	8040	8080	8080
INSTANTANEOUS	16000	110 %	17600	.001	.060	0.044	0.044	0.056	0.056	0.04	0.04
IPU	- % 15	+ % 15	16000	13600	18400	16400	16400	17300	17300	16400	16400
GROUND FAULT	800	150 %	1200	.36	.44	.413	.413	.41	.41	.413	.413
GFFU	- % 10	+ % 10	800	720	880	799	799	796	796	806	815

ISOLATION RESISTANCE 1,000 Vdc	POLE 1 (M1) (P1-P2P3P4)		POLE 2 (M2) (P2-P1P3P4)		POLE 3 (M3) (P3-P1P2P4)		POLE 4 (M4) (P4-P1P2P3)	
	AS FOUND	AS LEFT	AS FOUND	AS LEFT	AS FOUND	AS LEFT	AS FOUND	AS LEFT
LINE TO LINE	>2200	>2200	>2200	>2200	>2200	>2200	>2200	>2200
LINE TO GROUND	>2200	>2200	>2200	>2200	>2200	>2200	>2200	>2200
LINE TO LOAD	>2200	>2200	>2200	>2200	>2200	>2200	>2200	>2200

CONTACT RESISTANCE	AS FOUND	AS LEFT	AS FOUND	AS LEFT	AS FOUND	AS LEFT	AS FOUND	AS LEFT
MICROHMS	41	40	36	37	41	42	42	40

Level 2 Lessons Learned and Sequencing Tips

- Schedule kick off with vendors to build relationship and get durations for tasks, plus any pre-requisites, clarify working hours.
- Develop and implement an equipment protection plan.
- Label gear doors/protect and put hardware in a bag to keep from loosing them.
- Walk down the SCCS with the final approved copy prior to the Cx provider doing verification.
- Ensure space cleanliness, keep debris, tools, material off gear.
- Minimize dust producing activity, use clean sweep/sweeping compound, booties, no liquid policy.
- Set up cutting station outside of the electrical rooms, remove panels to drill/knockout.
- Energize AHU to start point-to-point on the system (possible temp power).
- Short Circuit Coordination Study (SCCS) and ARC Flash labels.
- Failed testing generates an Observation/Issue for tracking.
- Develop testing and documentation forms for electrical systems.
- Megger testing, Continuity checks, Torque logs.
- Photos (if allowed).
- Daily Cx Huddle 20-minute target for coordination, scheduling and constraints discussions.
- EPMS / BAS (BMS).



Level 3 System Start-up

- Includes pipe flushing, mechanical torque checks, insulation resistance, and grounding.
- Validates proper assembly and installation of like-kind systems (e.g., CRACs, PDUs)
- White Glove cleaning
- FOD inspection
- Safe first-time energization
- Documents start-up, voltage, rotation
- Factory start-up Technicians



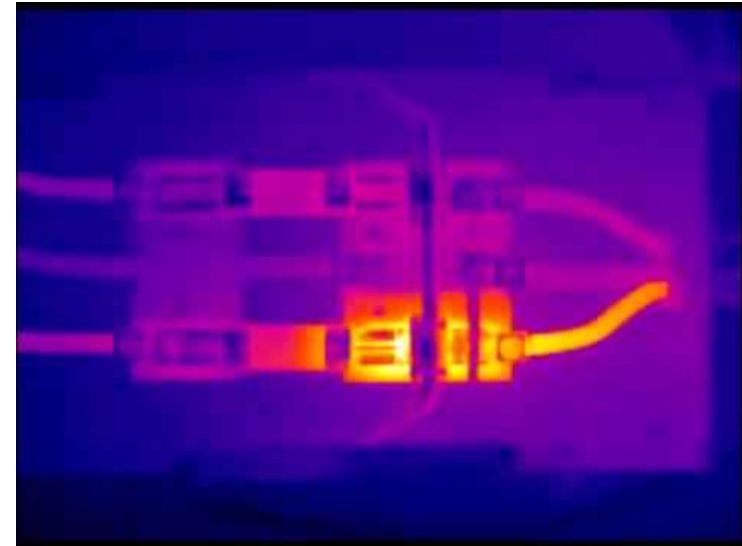
Level 3 Lessons Learned and Sequencing Tips

- First time energization Method of Procedure (MOP)
- Pre-punchlist, punch as you build
- Ensure Vendor paperwork is completed
- Coordinate vendor L3, troubleshooting, repair, replacement while managing LOTO and safety requirements.
- Verify pre-testing meets the specification requirements.
- Ensure start-up reports are useful and easy to read.

Level 4 Functional Testing

Validates

- Alarm response and setpoints.
 - Sequences of operation.
 - Environmental thresholds.
 - Automatic failover behavior of individual systems.
 - Ensure proper installation, documentation
 - Address Punch-list issues, sign and mark closed.
 - Component testing.
 - Proper PPE for testing.
- Address issues identified in a timely manner.
 - Closeout punch list during L4 testing.
 - Provide loadbank and switching teams to support Cx Provider.



Level 5 Integrated Systems Testing (IST)

- “Black out test” or “pull the plug test”.
- Simulates failure scenarios across multiple systems to ensure they work together.
- Ensures systems and reporting remains operational during a power event.

Confirms

- UPS to generator transitions.
- Network and power redundancy.
- Full building and operational continuity under stress.

*Required for Uptime Institute Tier Certification.

Level 6 Closeout, Turnover, Handover

- Start closeout early, get as-builts and O&M's from vendors and trade partners.
- Develop a training matrix to track and document required training and request curriculum for technical training.
- Develop an attic stock list for parts/material turnover.
- Final Commissioning Report and issue log closeout.
- Deliver O&M manuals, redlines, and training materials.
- Conduct seasonal testing and post-occupancy check-ins.
- Transfer system knowledge to facility operations team.

Wall of Shame



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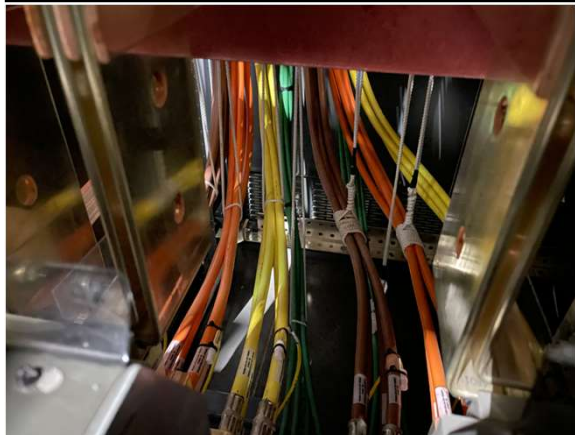


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Quality Installations



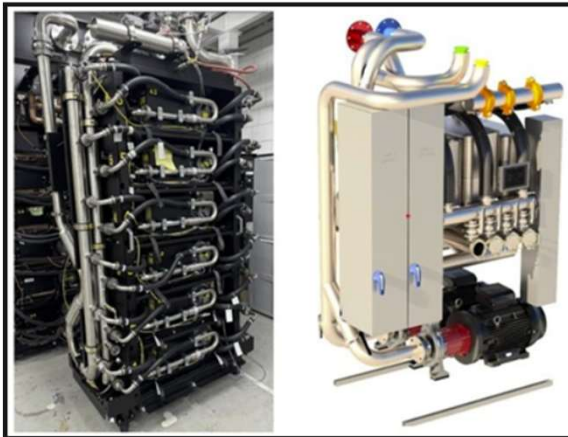
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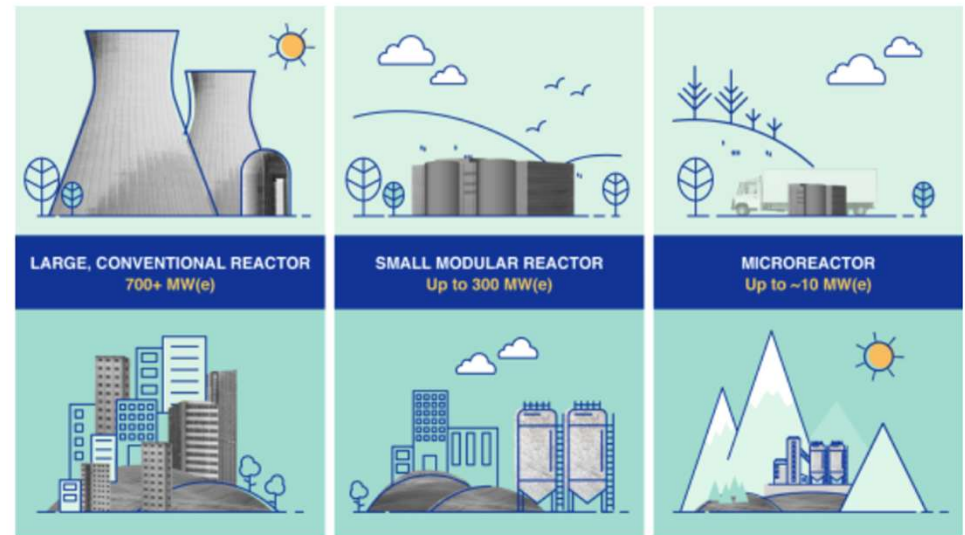
The Future of the Industry

- AI is a modern day Goldrush
- Pre-Fab skids in controlled environment (scope gaps NETA testing, local field support)
- Compact Nuclear (SMR's) <https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs>
- Immersion cooling
- ASHRAE Guideline 1.6P Cx of Data Centers
- Denser Racks



Google 1 MW rack May 2025

2025



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Questions?

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