AABC Commissioning Group

AIA Provider Number 50111116

With Great (Emergency) Power Comes Great Responsibility: Cx of Hospital Emergency Power Systems

Course Number: CXENERGY1818

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TLC Engineering for Architecture

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With Great (Emergency) Power Comes Great Responsibility:

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Commissioning Hospital Emergency Power Systems

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

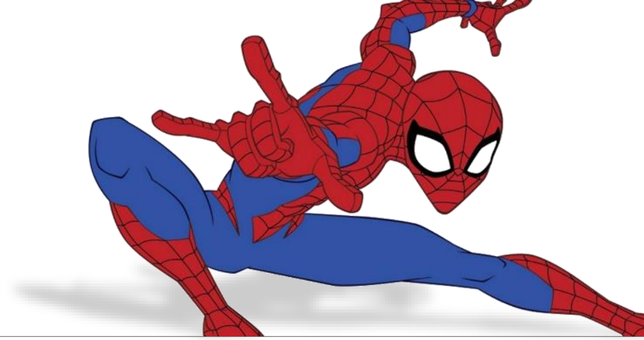
Like Spider-Man, the **Commissioning Authority** tries to stop disaster before it happens.

But their (our) importance is often not understood or appreciated until it's too late, especially concerning **commissioning Emergency Power Systems**.

Healthcare facilities may be able to deal with a temporary loss of utility power, but not a failure of the emergency power systems.

This session explains why and how our **superhero Cx Agent leads the Cx Team** to ensure emergency power systems are fully reliable to protect the health and safety of patients, staff and visitors.

Learning Objectives



At the end of the this course, participants will be able to:

1. Explain why 3rd party **independent commissioning of hospital emergency power systems is essential** to ensuring all systems within the hospital are fully operational and reliable in order to maintain the health, safety and welfare of all patients, staff and visitors.

2. Identify the **most common points of failure** of healthcare emergency power systems, discovered from case studies and lessons learned during the commissioning process.

3. Describe the urgency of **dialogue between the CxA and operations and maintenance staff** to ensure that operations staff is trained to operate the systems the way they were intended.

4. Follow the steps to fully test the emergency power systems, from **pre-functional testing** of each of the individual systems, through full **integration of systems testing** via simulating a normal power failure.

Your Friendly Neighborhood Commissioning Authority

What is THIS and What does it DO??

Terms:

Engine-Generator

Paralleling Switchgear

Emergency Power Supply (EPS)

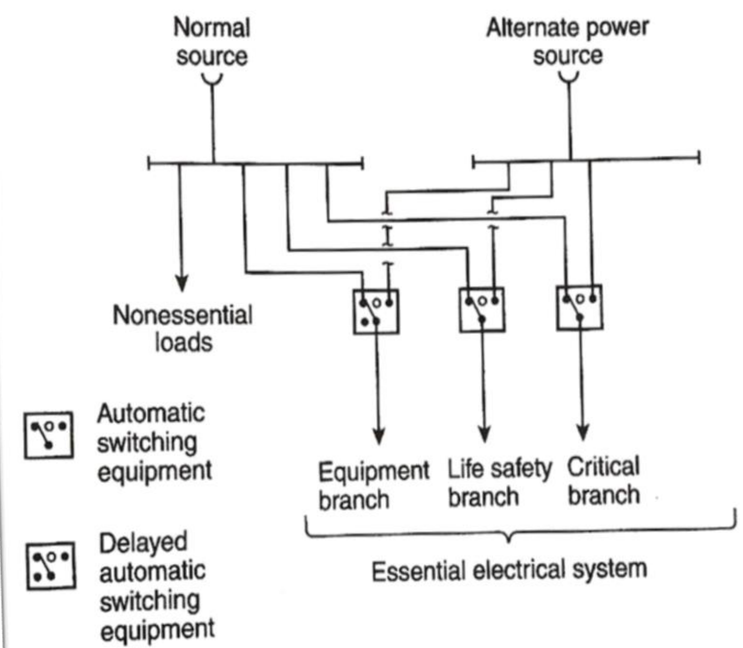
Automatic Transfer Switch

- Life Safety Branch
- Critical Branch
- Equipment Branch

Emergency Power Supply System (EPSS)

Normal Branch

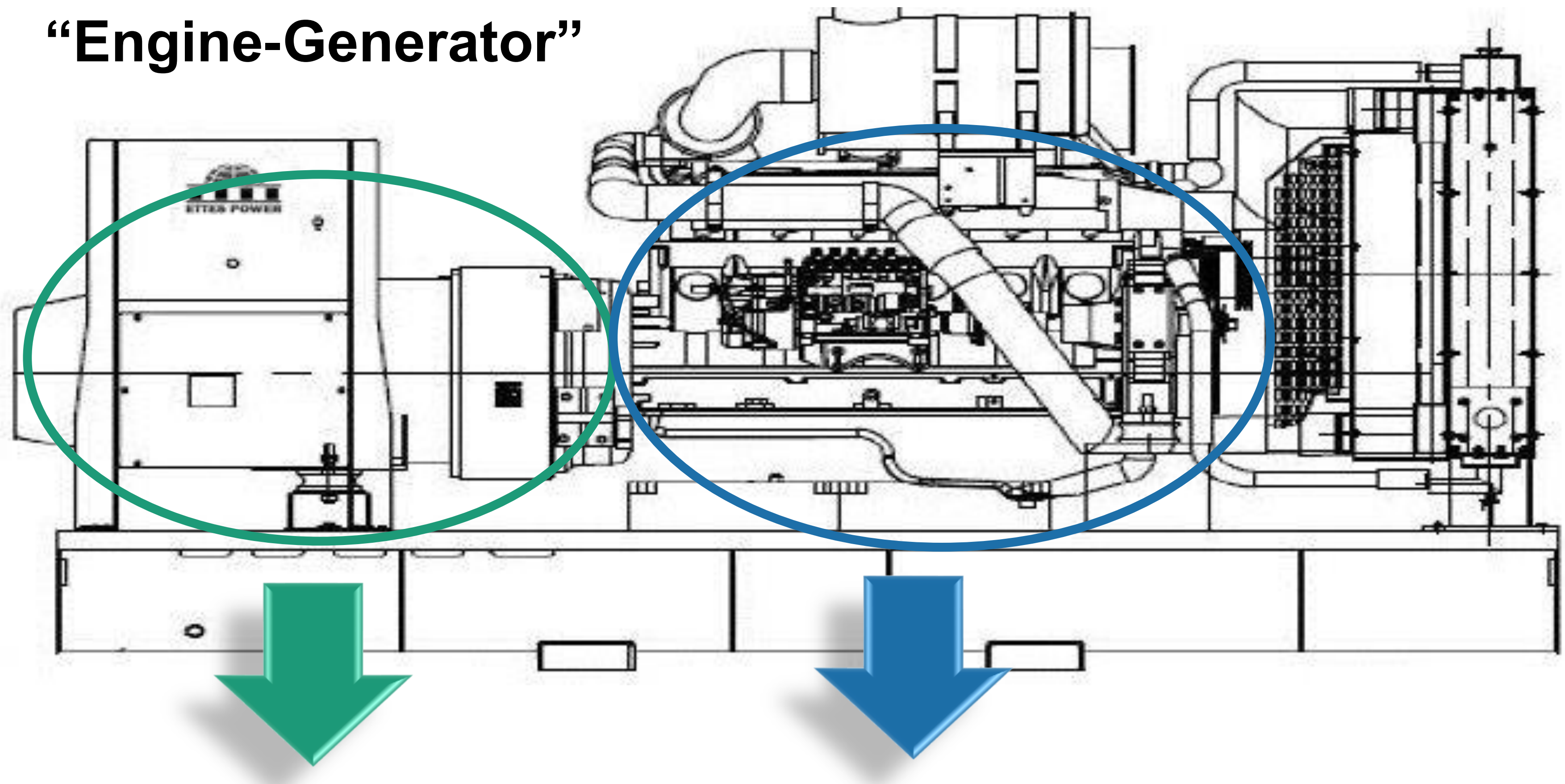
Non-Essential



Informational Note Figure 517.30, No. 1 Hospital — Minimum Requirement (greater than 150 kVA) for Transfer Switch Arrangement.

What is THIS and What does it DO??

“Engine-Generator”

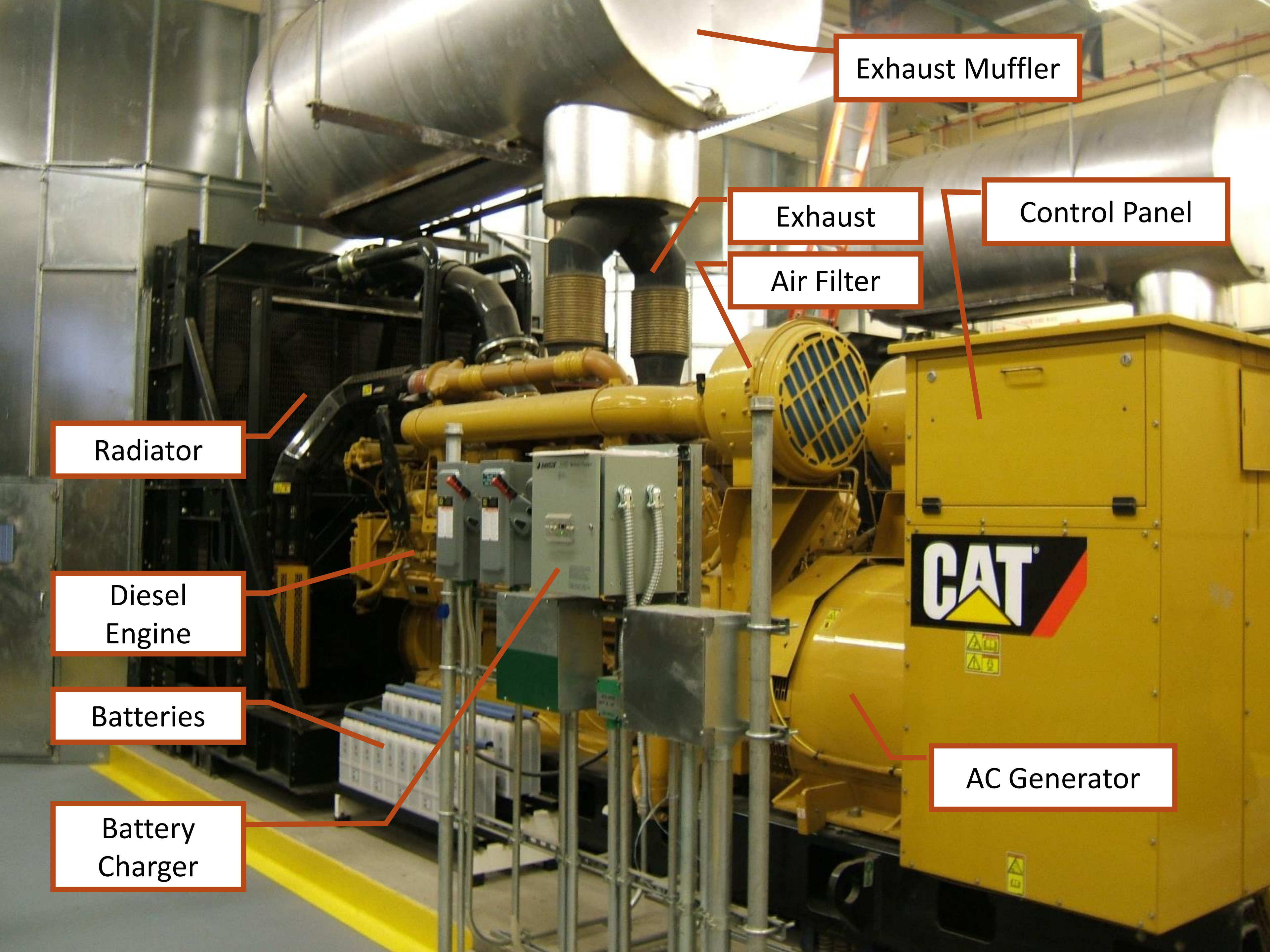


AC Generator

Diesel/Gas Engine

Accessories

Cooling Systems
Exhaust
Batteries
Fuel System


Exhaust Muffler
Exhaust
Control Panel
Air Filter
Radiator
Diesel Engine
Batteries
Battery Charger
AC Generator
CAT

What is THIS and What does it DO??

Fuel Systems

Main Fuel Tanks

Day Tanks

Engine-Generator

Diesel Fuel	
Pros	Cons
Cost Effective >150kW	Expensive <150kW
On-Site Storage = Reliability	Long Term Storage Maintenance, Cost
Proven Technology	Emissions

Natural Gas	
Pros	Cons
Cost Effective for small gen <150kW	More Expensive for large gens >150kW
Longer run times	Not as accepted, questions of reliability
Reduced environ impact	

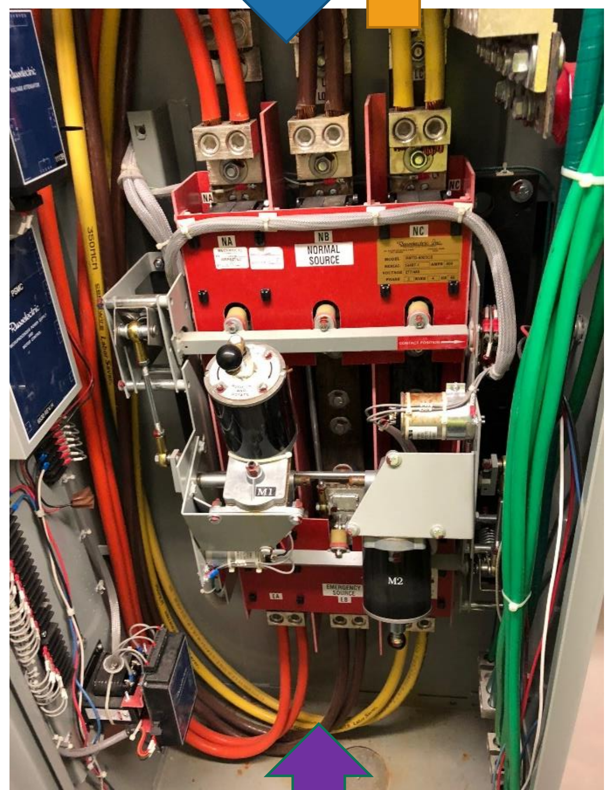
LP Fuel	
Pros	Cons
Cost Effective for small gen <150kW	More Expensive for large gens >150kW
On-site storage	Not as accepted, questions of reliability
Reduced environ impact	Design Challenges

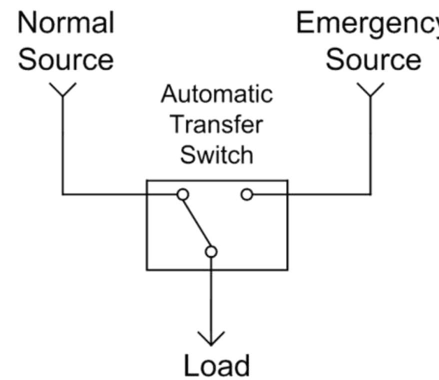
What is THIS and What does it DO??

Normal Power In (from Utility)

Power Out to Load

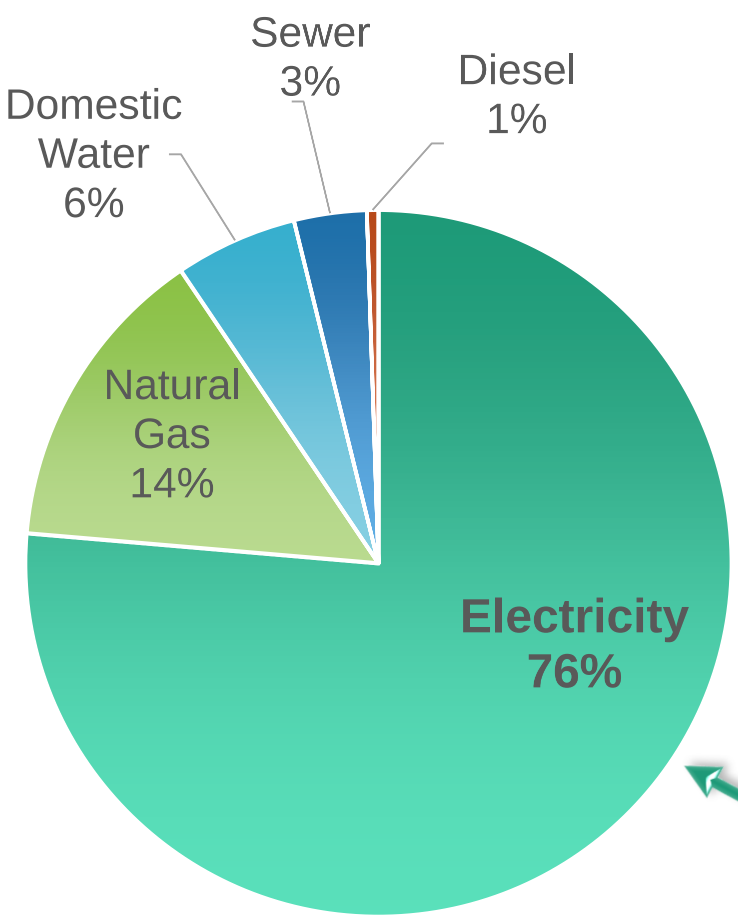
Automatic Transfer Switch





Emergency Power In (from EPS)

Why are we talking about this?



Average Hospital Spending on Utilities in United States:

Electricity is the single largest energy user in Hospitals

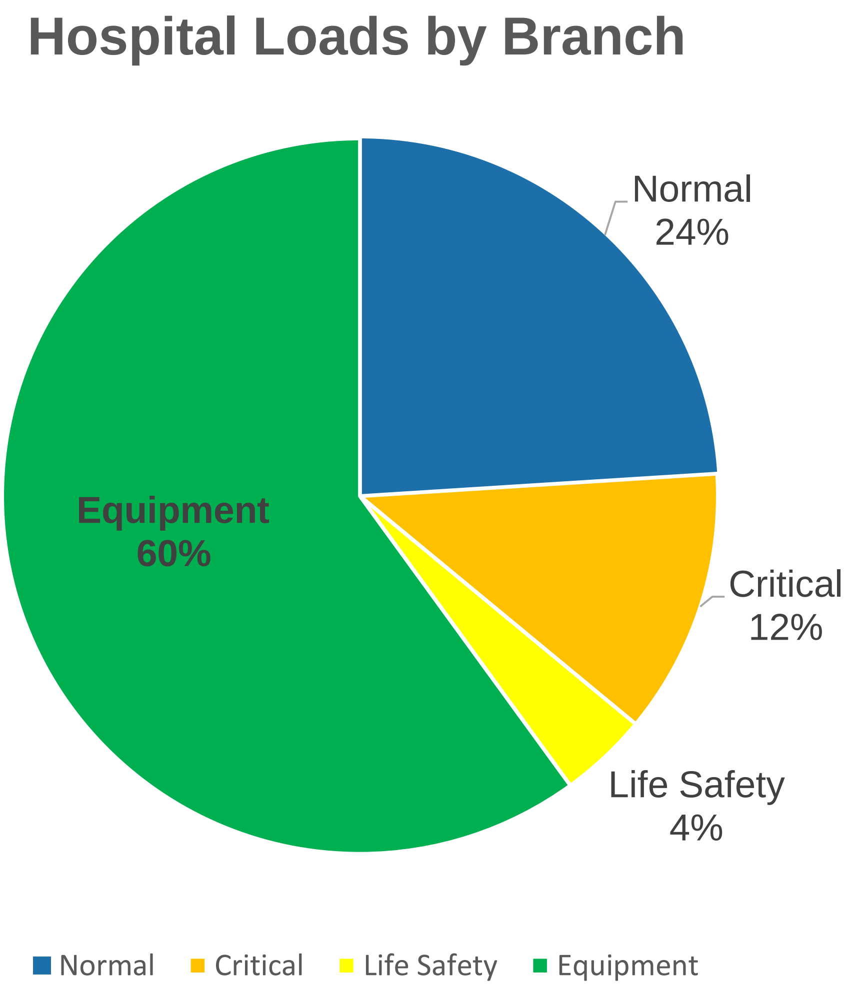
Chilled Water and HVAC Systems are the major driver for this electric usage.

Lets talk about Electricity…

ENGINEERING FOR ARCHITECTURE

Why are we talking about this?

Branch	Percentage of Peak Summer kWD
Life Safety	2-5%
Critical	8-15%
Equipment	50%-80%
Normal System	6% - 40%

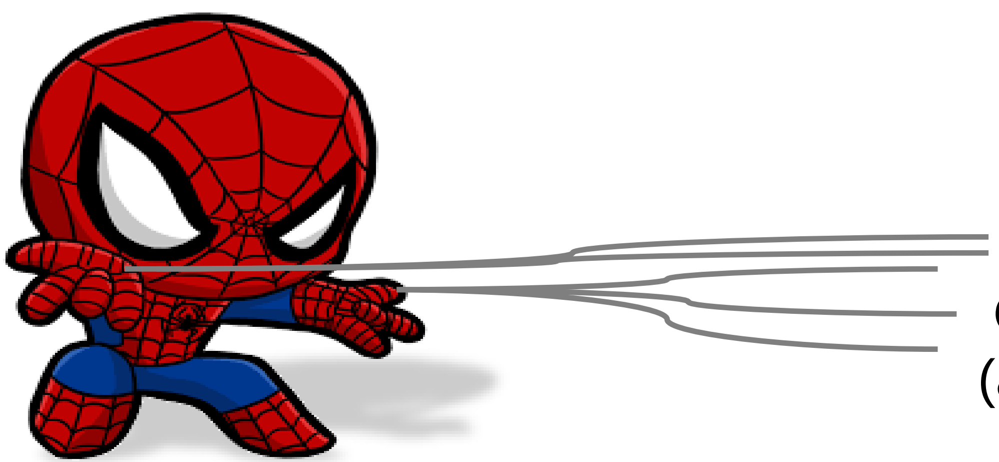


Based upon this analysis and additional data from many other facilities

Don’t I already Get This?

A/E/C Process

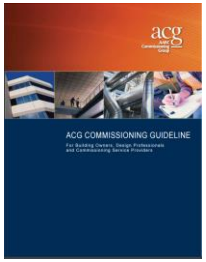
Schematic Design → Design Development → Construction Documents → Construction → Post-Occupancy



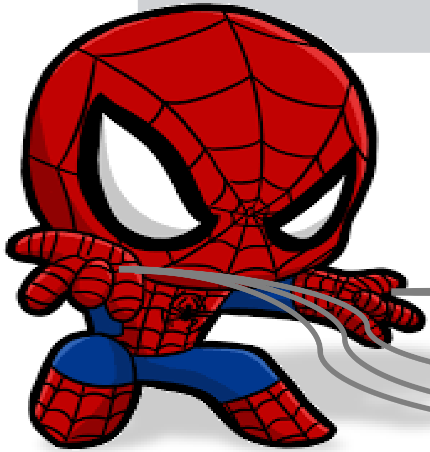
EOR’s “Construction Observation” does not (always) include testing

Don’t I already Get This?

Commissioning Process



Design Phase → Construction Phase → Acceptance Phase → Post-Occupancy Phase



Cx Process Goal:
Ensure a smooth transition from

Design → Construction → Occupancy

Commissioning is Required by Code… sort of

Design Phase

- Review OPR/ BOD
- **Cx Specs**
- **Develop Cx Plan** (draft)
- Design Reviews
- Update OPR
- Cx Scheduling
- **TAB Required in Const Docs**

Construction Phase

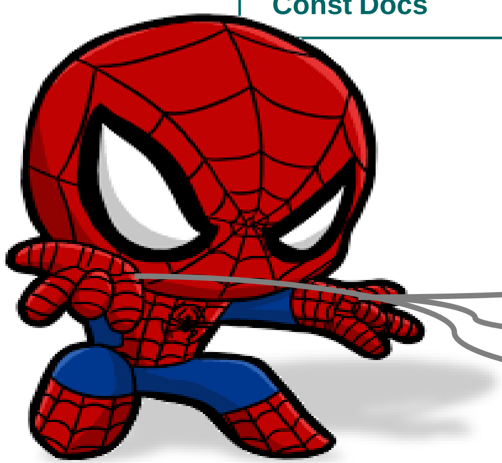
- Cx Kickoff
- Review Submittals
- **Refine Cx Plan**
- Site Observation
- Lead Cx Meetings
- **Start-up Testing**
- Issues Logs

Acceptance Phase

- **Test & Balance**
- **Functional Testing**
- Integration of Systems Testing
- Troubleshooting & Diagnostic
- Issues Logs
- **Prelim Cx Report**

Post-Occupancy Phase

- **O&M Manual**
- Owner Training
- Track open issues
- **Deferred Testing**
- 1 Yr Site Visits
- **Final Cx Report**
- **Record Drawings**
- **Final Balancing Report**



Commissioning is REQUIRED by CODE !!

Mechanical Systems (C408.2)
Service Water Heating (C408.2) – IECC 2015
Lighting Controls (C408.3)

ENGINEERING FOR ARCHITECTURE

What Fails and Why?

What Fails:

Batteries

Fuel Systems

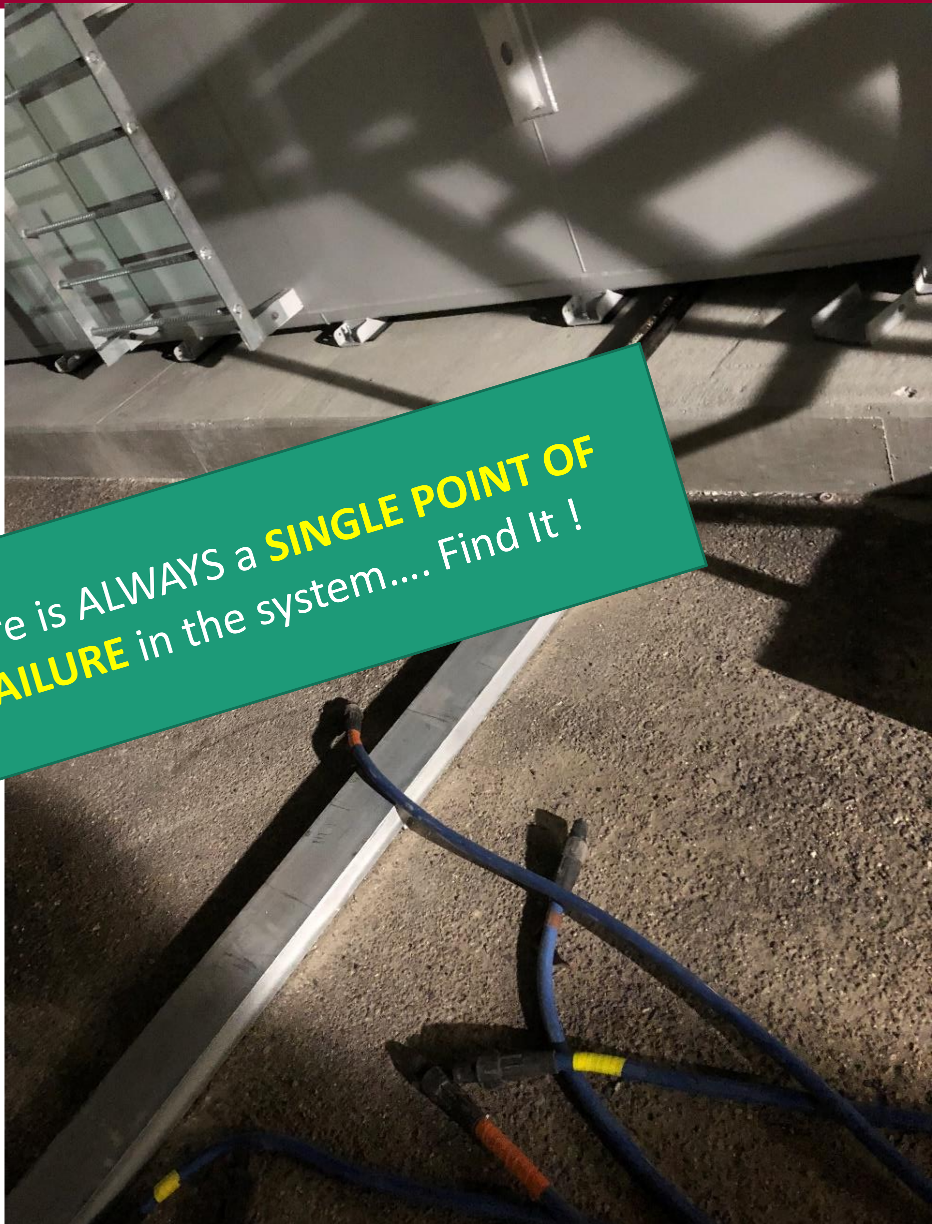
Single Points of Failure

Why:

Not considering the **single point of failure**

Lack of Testing

Lack of Preventative Maintenance



there is ALWAYS a **SINGLE POINT OF FAILURE** in the system…. Find It !

What Fails and Why?

Proper (initial) Commissioning

+

Ongoing Testing will solve these

Seven Reasons Why Generators Fail

Prime Power: http://www.primepower.com/blog/emergency-generator-inspection-seven-reasons-why-generators-fail/

1. **Battery Failure.** Battery failure is the most common cause of generator failure. In most cases, battery failure is caused by loose connections or sulfation buildup, a condition where lead sulfates accumulate on battery plates.
2. **Insufficient Coolant.** Generators are designed to shut down when they become too hot. When a generator has insufficient coolant, it is not prepared to operate for a long time, and could shut down when a facility needs it most.
3. **Fuel Leak.** Due to the smell they create, fuel leaks are usually detectable during regular maintenance. If they are only discovered after a genset is running, the problem could be a malfunctioning fuel pump, or a broken fuel line.
4. **Oil Leak.** Oil leaks are caused by wet stacking, a condition where oil, fuel and other liquids build up in a generator's exhaust pipes due to carbonized fuel injection tips, and faulty crankcase breathers that release too much oil as it vents.
5. **Control Setting Errors.** Many generators fail to start because of their controls being left at the wrong setting following maintenance or testing. If the proper resetting procedure is not followed, a control error could also occur after a fault shutdown.
6. **Fuel Bleed Back.** When fuel bleeds back into a generator's fuel tank instead of going to the engine, air in the injection mechanism or faulty check valves could be the cause. In either case, the generator behaves as it were out of fuel.
7. **Empty Fuel Tank.** Stuck fuel gauges and fuel gauges that read fuel levels incorrectly commonly cause empty fuel tanks. Empty tanks can also result from testing a generator month after month without checking its fuel level.

ENGINEERING FOR ARCHITECTURE

- Ben Parker

Design Phase

Design Phase

What does the CxA Actually Do?

Review OPR & BOD

Review Construction Documents

Cx Specifications

Develop the Cx Plan

Pre-Functional Checklists

Functional Performance Checklists

Part of the Team

Design Phase

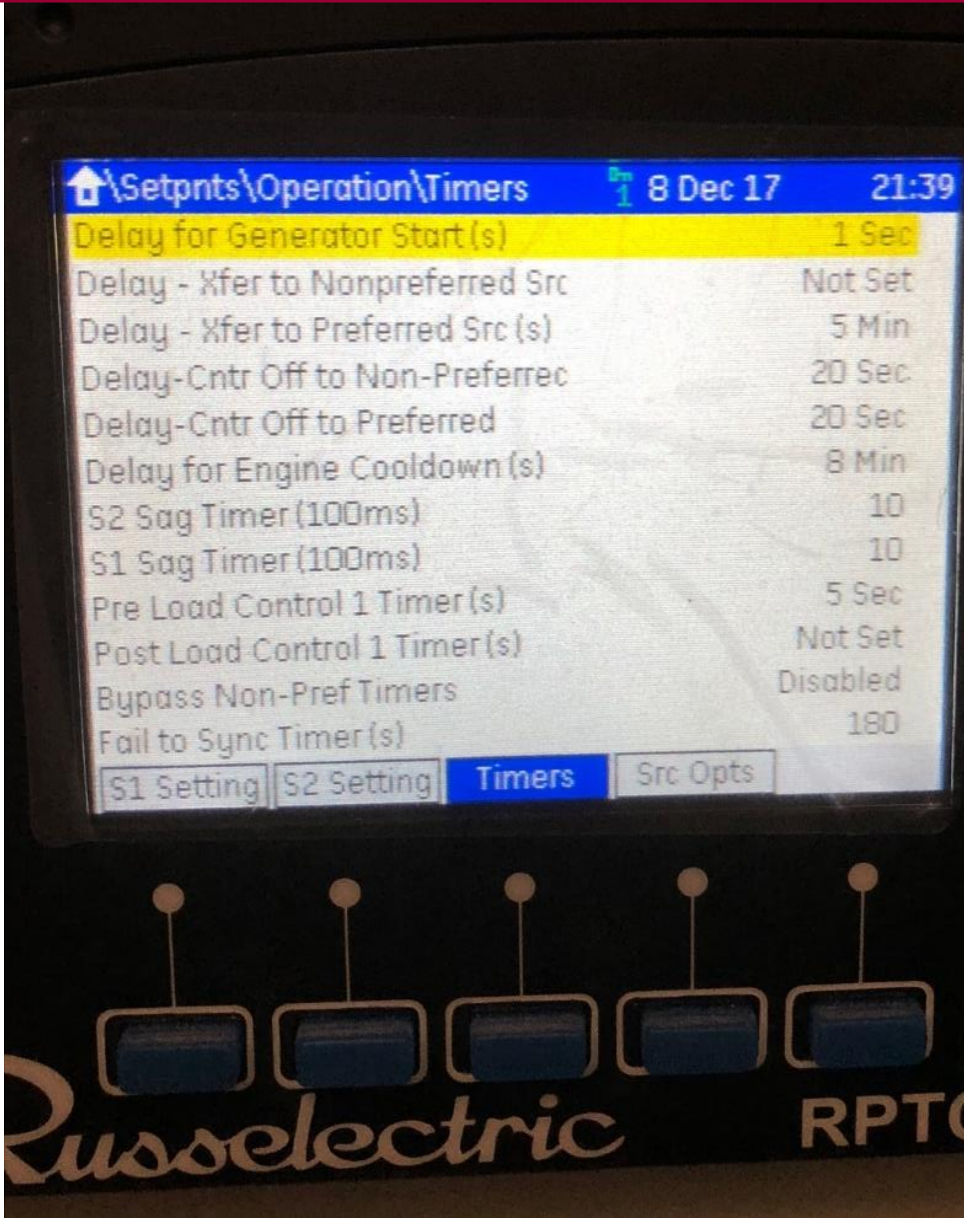
Sequences of Operation

Common in HVAC

Rare in EPSS

- Detailed sequence of operations
- Load shed sequences
- ATS time delay settings

Often not specified in Contract Documents



Sequence of Operations

"Upon Loss of Utility Power…"

AUTOMATIC TRANSFER SWITCH SEQUENCE OF OPERATION

THE FOLLOWING SEQUENCE OF OPERATION SHALL BE USED FOR PROGRAMING, SETUP AND TESTING OF ALL NEW AUTOMATIC TRANSFERSWITCHES, EXISTING AUTOMATIC TRANSFER SWITCHES AND EXISTING CUMMINS EMERGENCY POWER CONTROL SYSTEM.

NOTE: ALL FOUR ENGINE GENERATOR, PARALLELING GEAR, ALL ACCESSORIES, AND CONTROL EQUIPMENT ARE EXISITNG. ONLY THE AUTOMATIC TRANSFER SWITCHES ARE NEW.

UPON LOSS OF NORMAL POWER – WHETHER VIA OPENING OF A NORMAL FEEDER BREAKER OR LOSS OF UTILITY POWER (CUTOUT = 85% OF NOMINAL VOLTAGE) - THE FOLLOWING SHALL OCCUR:

1. PRE-PROGRAMMED ENGINE-START DELAY TIMER SHALLY START.
2. AFTER ENGINE START DELAY, ATS SHALL SEND START SIGNAL TO THE ENGIN GENERATORS (VIA EXISTING HARD WIRED START SIGNAL WIRING)
3. ALL (4) FOUR EXISTING ENGINE-GENERATORS SHALL START, AND PARALLEL T COMMON BUSS AS THEY REACH VOLTAGE, FREQUENCY AND SPEED.
4. ONCE THE FIRST ENGINE-GENERATOR COMES ON-LINE ALL PRIORITY 1 TRANS SWITCHES (LIFE SAFETY) SHALL AUTOMATICALLY TRANSFER FROM NORMAL POSITION TO EMERGENCY POSITION, WITHIN 10 SECONDS OF LOSS OF POWER
5. ONCE THE SECOND ENGINE GENERATOR PARALLELS TO THE BUSS, ALL PRIORI TRANSFER SWITCHES (CRITICAL BRANCH) SHALL TRANSFER FROM NORMAL POSITION TO EMERGENCY POSITION, WITHIN 10 SECONDS OF LOSS OF POWER.
6. ONCE THE THIRD ENGINE GENERATOR PARALLELS TO THE BUSS, ALL PRIORITY 3TRANSFER SWITCHES (EQUIPMENT BRANCH) SHALL TRANSFER FROM NORMAL POSITION TO EMERGENCY POSITION. EQUIPMENT BRANCH TRANSFER SWITCHES WITH A CENTER-POSITION TIME-DELAY SHALL SEQUENCE THRU THAT OPERATIO DURING THE TRANSFER
7. THE PARALLELED ENGINE-GENERATORS SHALL SHARE LOAD (APPROXIMATELY) EQUALLY.
8. ONCE NORMAL POWER IS RESTORED (PICKUP = 90% NOMINAL VOLTAGE), INITIATE RE-TRANSER TO NORMAL TIME DELAY COUNTDOWN, TO ENSURE NORMAL POWER IS STABLE AND FULLY RESTORED.
9. ONCE COUNTDOWN IS COMPLETE, TRANSFER ALL ATSS FROM EMERGENCY TO NORMAL. EQUIPMENT BRANCH TRANSFER SWITCHES WITH A CENTER-POSITION TIME-DELAY SHALL SEQUENCE THRU THAT OPERATION DURING THE TRANSFER.
10. AFTER ALL TRANSFER SWITCHES ARE TRANSFERRED TO NORMAL POWER, INITIATE PER-PROGRAMMED ENGINE-COOL DOWN COUNT DOWN.

LOAD SHED SEQUENCE OF OPERATION

1. UPON UNEXPCTED LOSS OF ONE OF THE FOUR EXISTING ENGINE-GENERATORS, NO ACTION SHALL OCCUR; THE ENTIRE EPSS LOAD CAN BE SERVED WITH THREE

Load Shed Sequence

GENERATORS IN SERVICE. HOWEVER, THE EMERGENCY POWER DEMAND-LOAD SENSING SYSTEMS SHALL DETERMINE IF THE LOAD CAN BE CARRIED BY THE REMAINING ENGINE-GENERATORS AND IF THE ENTIRE LOAD CANNOT BE CARRIED, THE LOAD SHED SEQUENCE SHALL COMMENCE STARTING WITH PRIORITY 3 LOADS.

2. UPON UNEXPCTED LOSS OF TWO OF THE FOUR EXISTING ENGINE-GENERATORS (CUTOUT = 85% OF NOMINAL VOLTAGE), THE PRIORITY 3 (EQUIPMENT BRANCH) TRANSFER SWITCHES SHALL BE AUTOMATICALLY TRANSFERRED TO CENTER POSITION. IF NORMAL POWER IS AVAILABLE, ALL TRANSFER SWITCHES SHALL SWITCH TO NORMAL POSITION. THE EMERGENCY POWER DEMAND-LOAD SENSING SYSTEMS SHALL DETERMINE IF THE LOAD CAN BE CARRIED BY THE REMAINING ENGINE-GENERATORS; IF THE LOAD CAN BE CARRIED BY THE REMAINING ENGINE-GENERATORS, THE PRIORITY 3 TRANSFER SWITCHES MAY BE MANUALLY RE-ADDED.
3. UPON UNEXPCTED LOSS OF THREE OF THE FOUR EXISTING ENGINE-GENERATORS (CUTOUT = 85% OF NOMINAL VOLTAGE), THE PRIORITY 2 (CRITICAL BRANCH) AUTOMATICALLY TRANSFERRED TO NORMAL POSITION. IF PRIORITY 3 LOADS ARE CONNECTED OR HAVE BEEN READDED, THEY SHALL ALSO BE AUTOMATICALLY SHED AS INDICATED ABOVE. THE EMERGENCY POWER DEMAND-LOAD SENSING SYSTEMS SHALL DETERMINE IF THE LOAD CAN BE CARRIED BY THE REMAINING ENGINE-GENERATORS; IF THE LOAD CAN BE CARRIED BY THE REMAINING ENGINE-GENERATORS, THE PRIORITY 2 AND PRIORITY 3 TRANSFER SWITCHES MAY BE MANUALLY RE-ADDED.

AUTOMATIC TRANSFER SWITCH SETTINGS: ALL NEW AUTOMATIC TRANSFER SWITCHES SHALL BE PROGRAMMED WITH THE FOLLOWING TIME DELAY SETTINGS. SETTINGS MAY BE ADJUSTED DURING COMMISSIONING AND/OR AHCA TESTING TO ENSURE THAT LIFE SAFETY AND CRITICAL BRANCH TRANSFER SWITCHES COME ONLINE WITHIN 10 SECONDS OF LOSS OF POWER.

LIFE SAFETY BRANCH TRANSFER SWITCHES

ENGINE START TIME DELAY:	1.0 SECONDS (AJUSTABLE 0 - 6 SECONDS)
TRANSFER TO EMERGENCY TIME DELAY:	0 SECONDS (AJUSTABLE 0 – 60 MINUTES)
EMERGENCY SOURCE STABILIZATION TIME DELAY:	0 SECONDS (ADJUSTABLE 0 - 6 SECONDS)
DELAYED TRANSITION LOAD DISCONNECT (CENTER POSITION) TIME DELAY:	NOT APPLICABLE
RETRANSFER TO NORMAL TIME DELAY (POWER FAILURE MODE):	15 MINUTES (ADJUSTABLE 0 – 60 MINUTES
RETRANSFER TO NORMAL TIME DELAY (TEST MODE):	30 SECONDS (ADJUSTABLE 0 – 10 HOURS
UNLOADED RUNNING TIME DELAY FOR ENGINE COOL DOWN:	5 MINUTES (ADJUSTABLE 0 – 60 MINUTES

ATS Settings

CRITICAL BRANCH TRANSFER SWITCHES

ENGINE START TIME DELAY:	1.0 SECONDS (AJUSTABLE 0 - 6 SECONDS)
TRANSFER TO EMERGENCY TIME DELAY:	0 SECONDS (AJUSTABLE 0 – 60 MINUTES)
EMERGENCY SOURCE STABILIZATION TIME DELAY:	0 SECONDS (ADJUSTABLE 0 - 6 SECONDS)
DELAYED TRANSITION LOAD DISCONNECT (CENTER POSITION) TIME DELAY:	NOT APPLICABLE
RETRANSFER TO NORMAL TIME DELAY (POWER FAILURE MODE):	15 MINUTES (ADJUSTABLE 0 – 60 MINUTES)
RETRANSFER TO NORMAL TIME DELAY (TEST MODE):	30 SECONDS (ADJUSTABLE 0 – 10 HOURS)
UNLOADED RUNNING TIME DELAY FOR ENGINE COOL DOWN:	5 MINUTES (ADJUSTABLE 0 – 60 MINUTES)

EQUIPMENT BRANCH TRANSFER SWITCHES

ENGINE START TIME DELAY:	1.0 SECONDS (AJUSTABLE 0 - 6 SECONDS)
TRANSFER TO EMERGENCY TIME DELAY:	0 SECONDS (AJUSTABLE 0 – 60 MINUTES)
EMERGENCY SOURCE STABILIZATION TIME DELAY:	0 SECONDS (ADJUSTABLE 0 - 6 SECONDS)
DELAYED TRANSITION LOAD DISCONNECT (CENTER POSITION) TIME DELAY:	30 SECONDS (ADJUSTABLE 0 – 5 MINS)
RETRANSFER TO NORMAL TIME DELAY (POWER FAILURE MODE):	15 MINUTES (ADJUSTABLE 0 – 60 MINUTES)
RETRANSFER TO NORMAL TIME DELAY (TEST MODE):	30 SECONDS (ADJUSTABLE 0 – 10 HOURS)
UNLOADED RUNNING TIME DELAY FOR ENGINE COOL DOWN:	5 MINUTES (ADJUSTABLE 0 – 60 MINUTES)
PRE/POST TRANSFER SIGNAL TIME DELAY, FOR SELECTIVE LOAD DISCONNECT WITH PROGRAMMABLE BYPASS ON SOURCE FAILURE. (PROVIDE FOR ELEVATOR ATSS):	30 SECONDS* (ADJUSTABLE 0 – 5 MINS)

*COORDINATE WITH HOSPITAL AND ELEVATOR VENDOR. THIS SIGNAL CAN BE USED TO DRIVE RELAY OR DT CONTACTS AS REQUIRED.

ENGINEERING FOR ARCHITECTURE

What is the Risk?

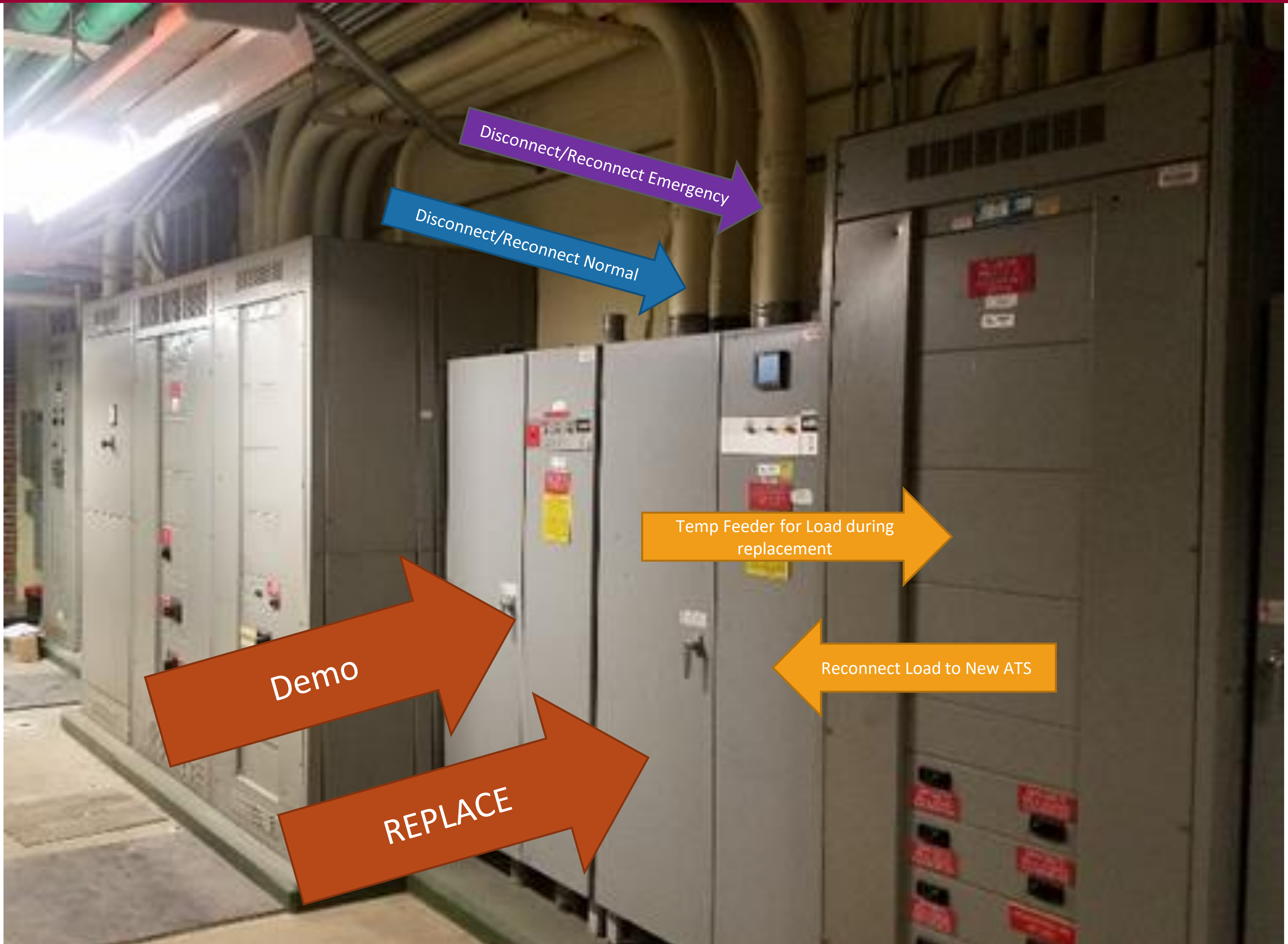
Patient Safety!

Things that aren't always thought about:

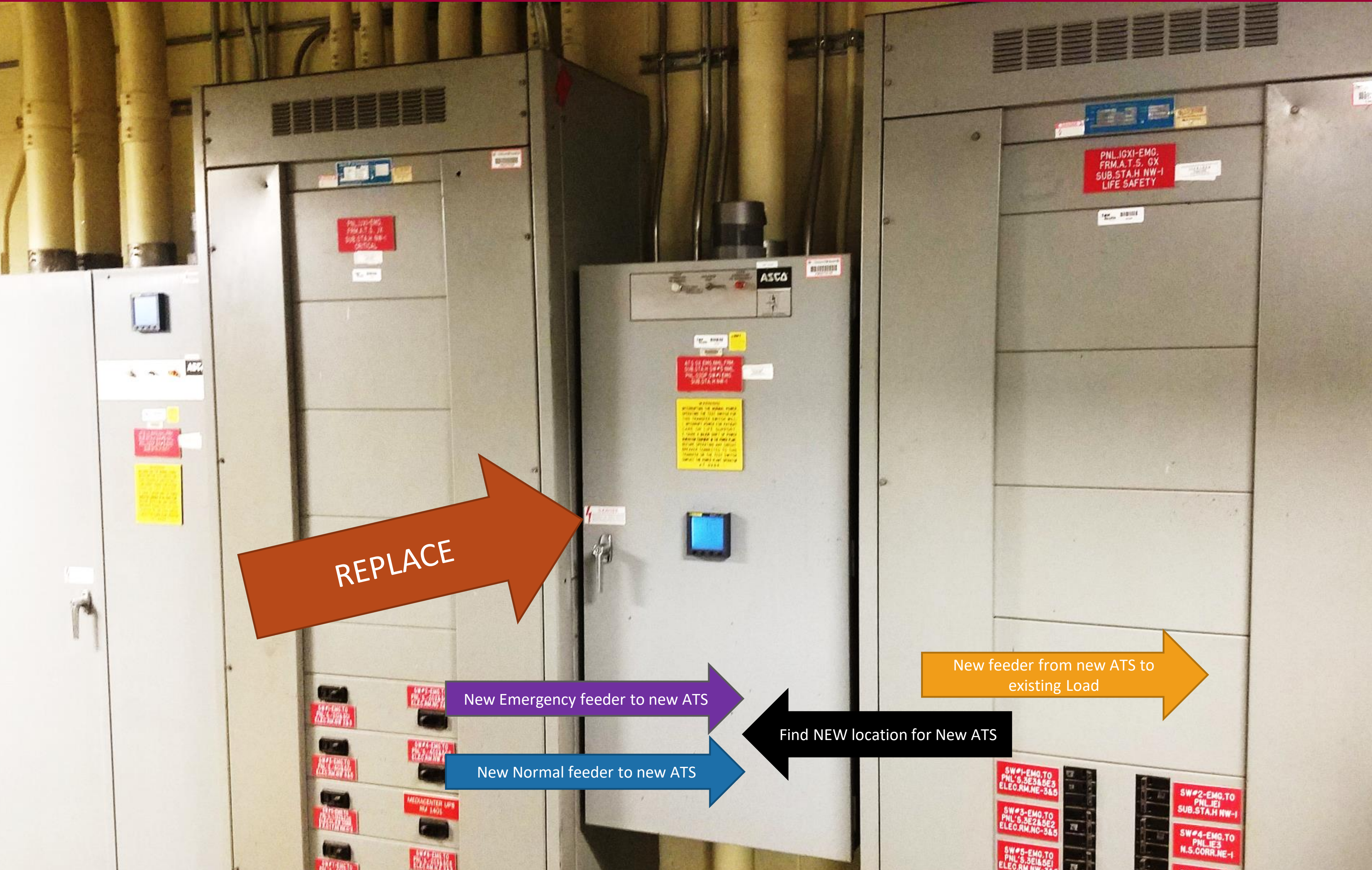
- Do I have EVERYTHING needed for an extended outage?
- Single Points of Failure
- Ease of ongoing Maintenance & Testing
- Training

Case Study Example: Phasing

Case Study Example: Phasing



Case Study Example: Phasing



Construction Phase

Construction Phase

What does the CxA Actually Do?

Review Submittals

Update Cx Plan

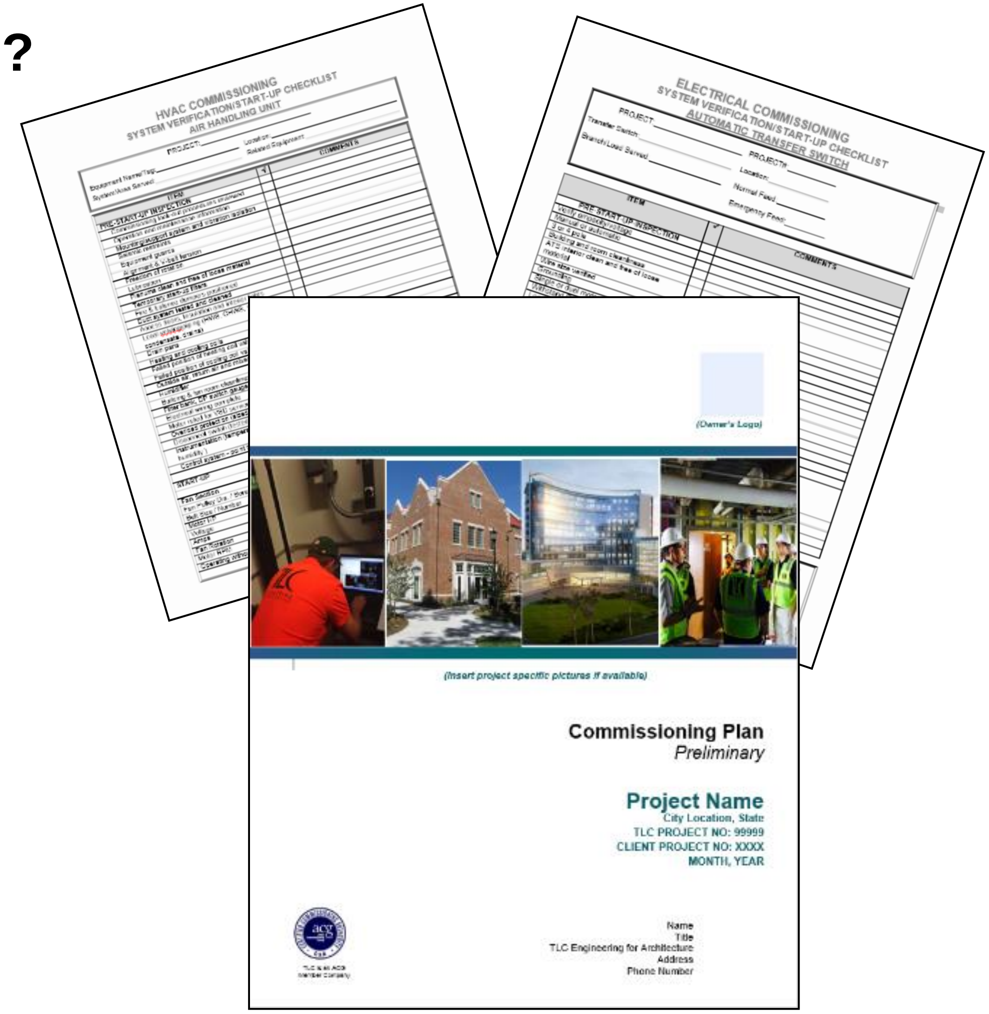
Kick Off Meeting

Draft FPTs

Construction Observation

Pre-Functional Checklists

Issues Logs

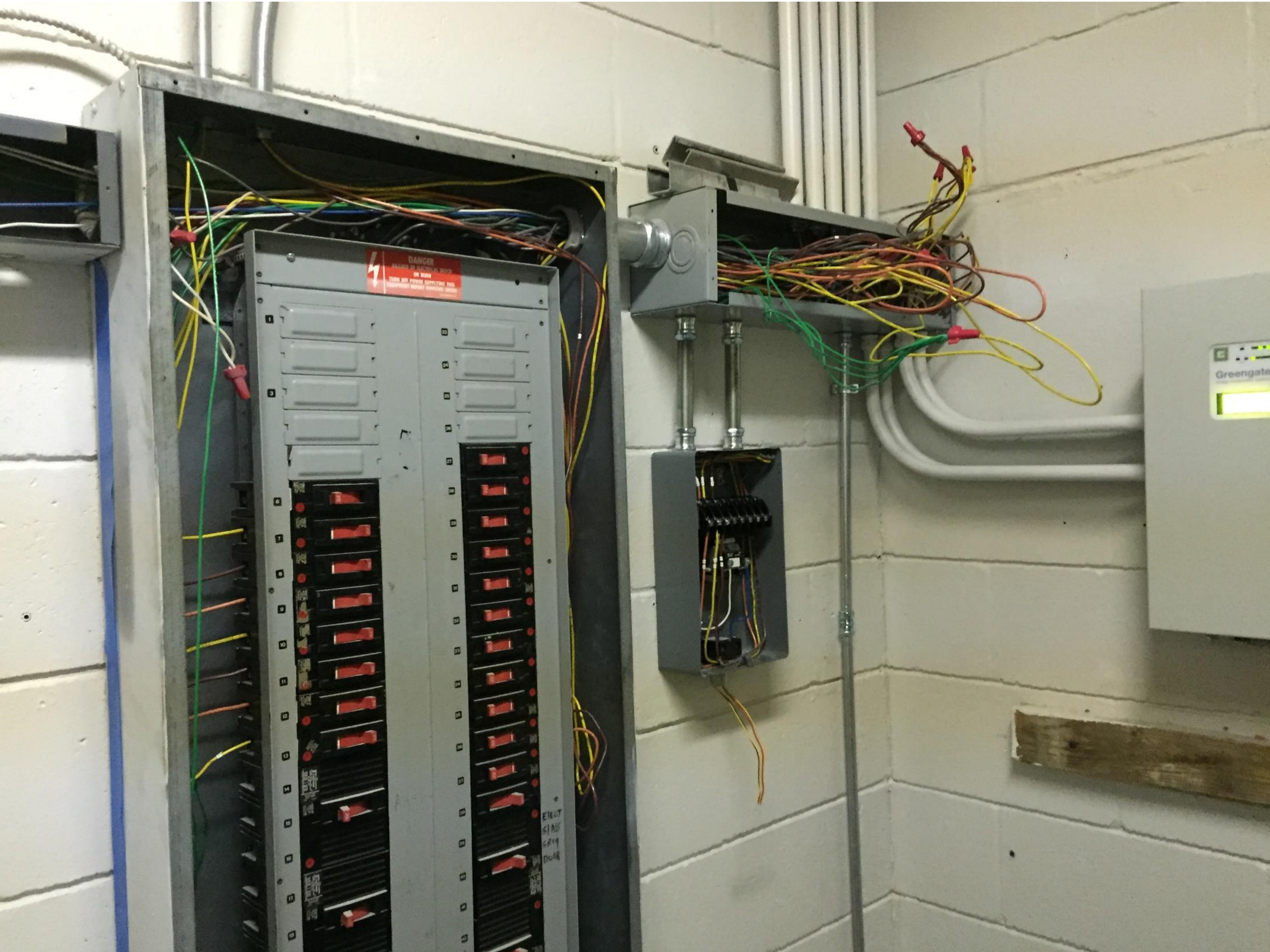


Construction Phase

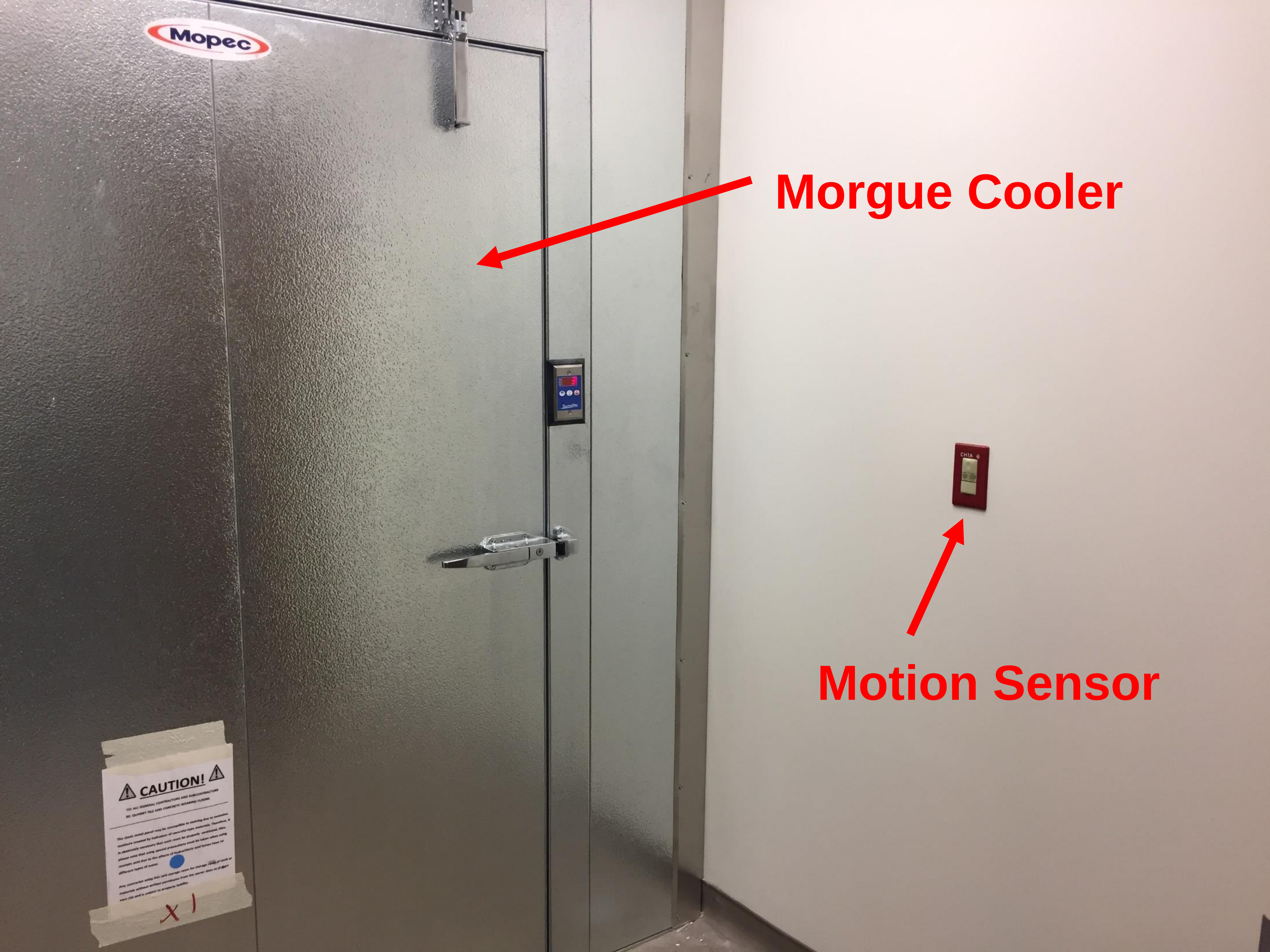
Things I can't Un-See


EXIT

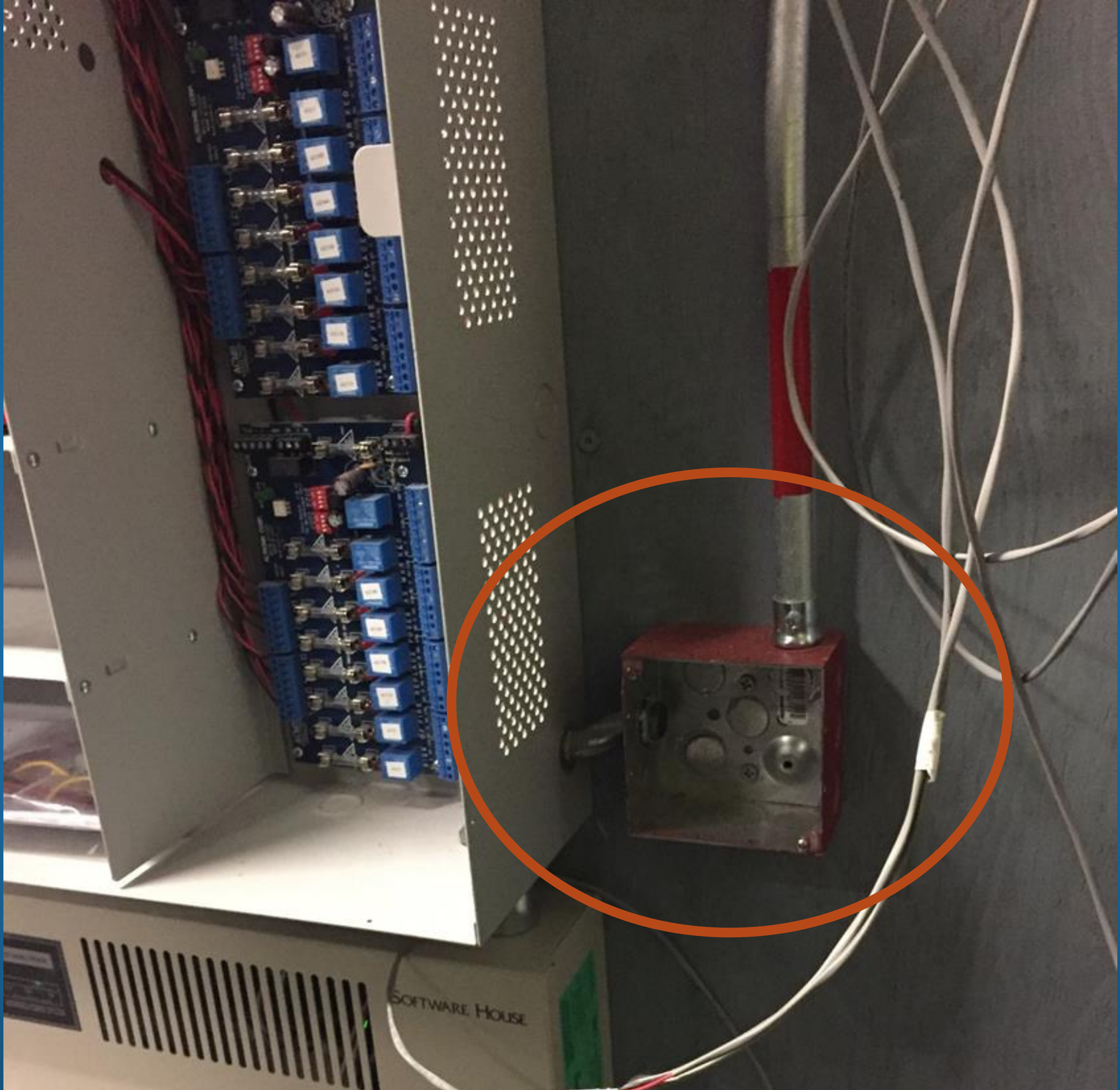

RUTE


DANGER
OR BURN
TURN OFF POWER SUPPLYING THIS
Greengate


CAUTION
VOLTAGE MAY BE PRESENT FROM MORE THAN ONE SOURCE AND SHOULD BE DISCONNECTED FOR SERVICING.
ATTENTION
PEUT ÊTRE SOUS TENSION DE PLUS D'UNE SOURCE D'ALIMENTATION ÉLECTRIQUE. COUPER TOUTES LES SOURCES D'ALIMENTATION AVANT LE DÉPANNAGE.
DO NOT STICK HAND IN HOLE
HAND @ 40HZ
O OFF


Mopec
CAUTION!
Morgue Cooler
Motion Sensor

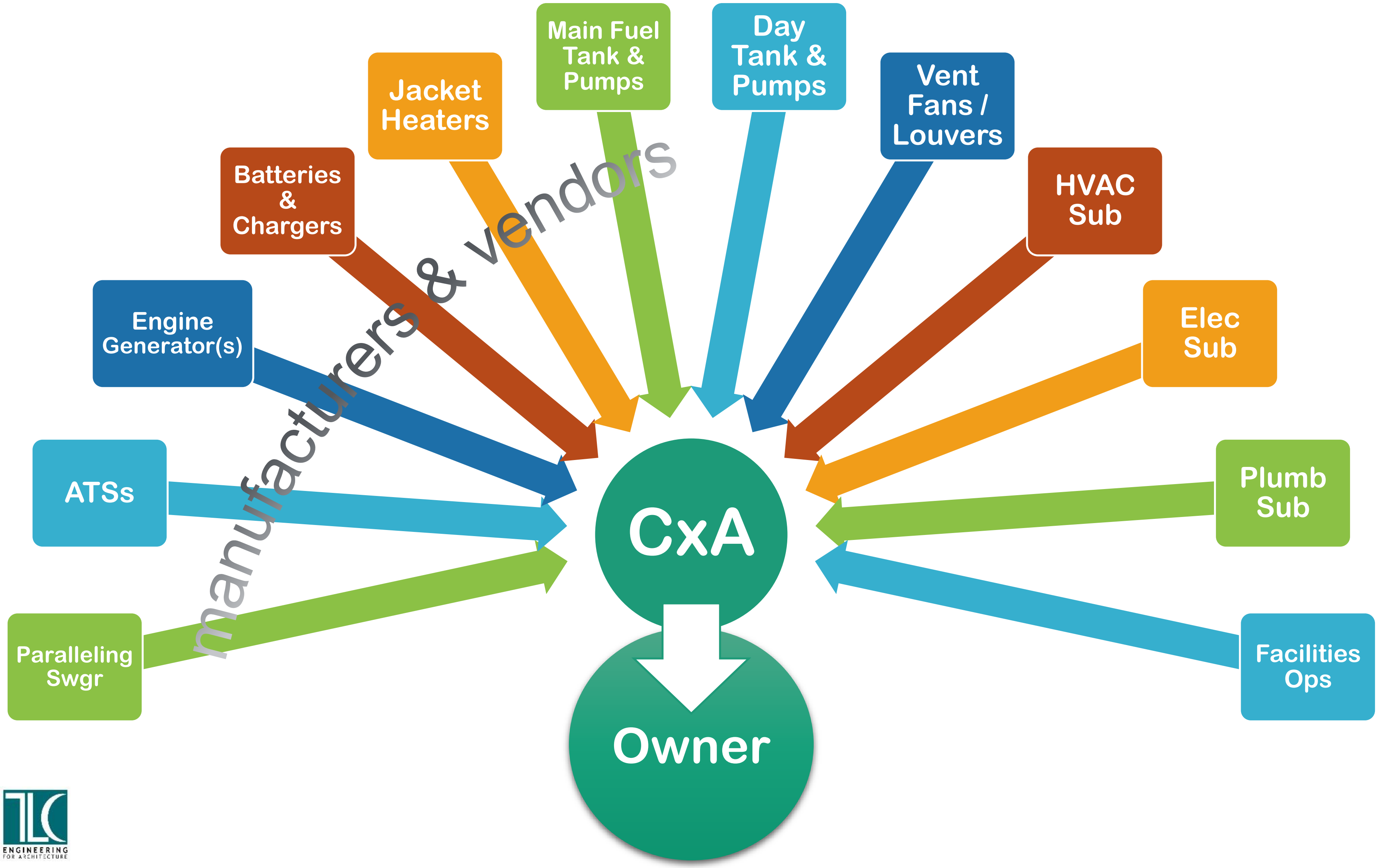

MEDICAL AIR INTAKE


SOFTWARE HOUSE


IN THE EVENT OF FIRE
R Rescue
Rescue Patients / Remove Victims and Close Door
A Alarm
Pull Fire Alarm/ Call 427-2222 Code Red
C Confine
Close all Doors and Windows
E Extinguish
Extinguish the Fire if Possible
Evacuate Patients if Necessary
Do Not Endanger Yourself or Others in the Process
FIRE ALARM
PULL DOWN
Simplex
POWER OFF
PUSH BUTTON
Added During Construction Phase


SENS

"Not in My Scope…"



Construction Phase

Photo-Finish !!

Scheduling and Coordinating

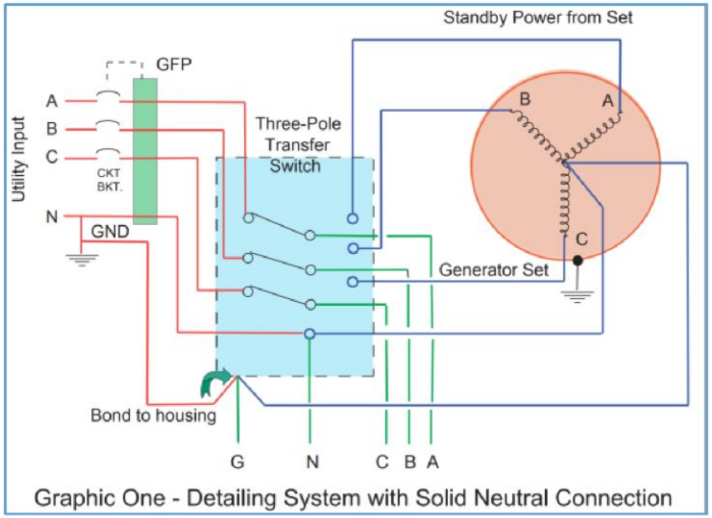
Pre-Functional Testing

Functional Testing

AHJ inspections

Case Study Example: Grounding

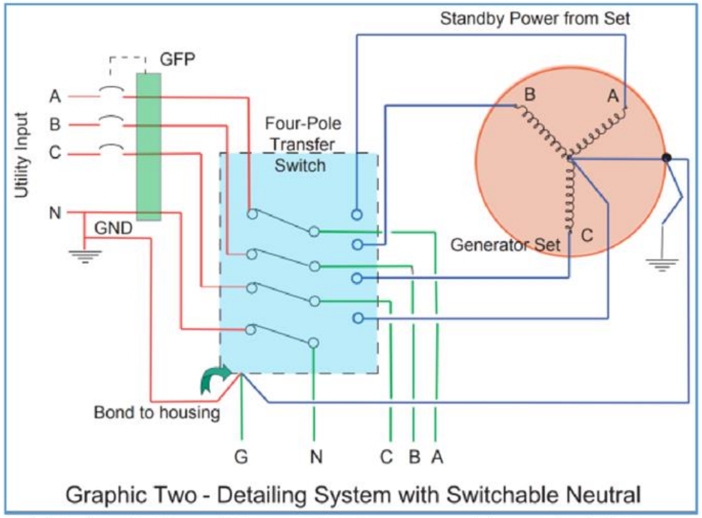
Case Study Example: Grounding



Ex: 3-Pole ATS, no neutral-ground at Gen

3-Pole ATS: switches A-B-C phases only; Neutral Solidly Connected

"Non-Separately Derived" Grounding: Neutral & Ground <u>not</u> connected at EPS



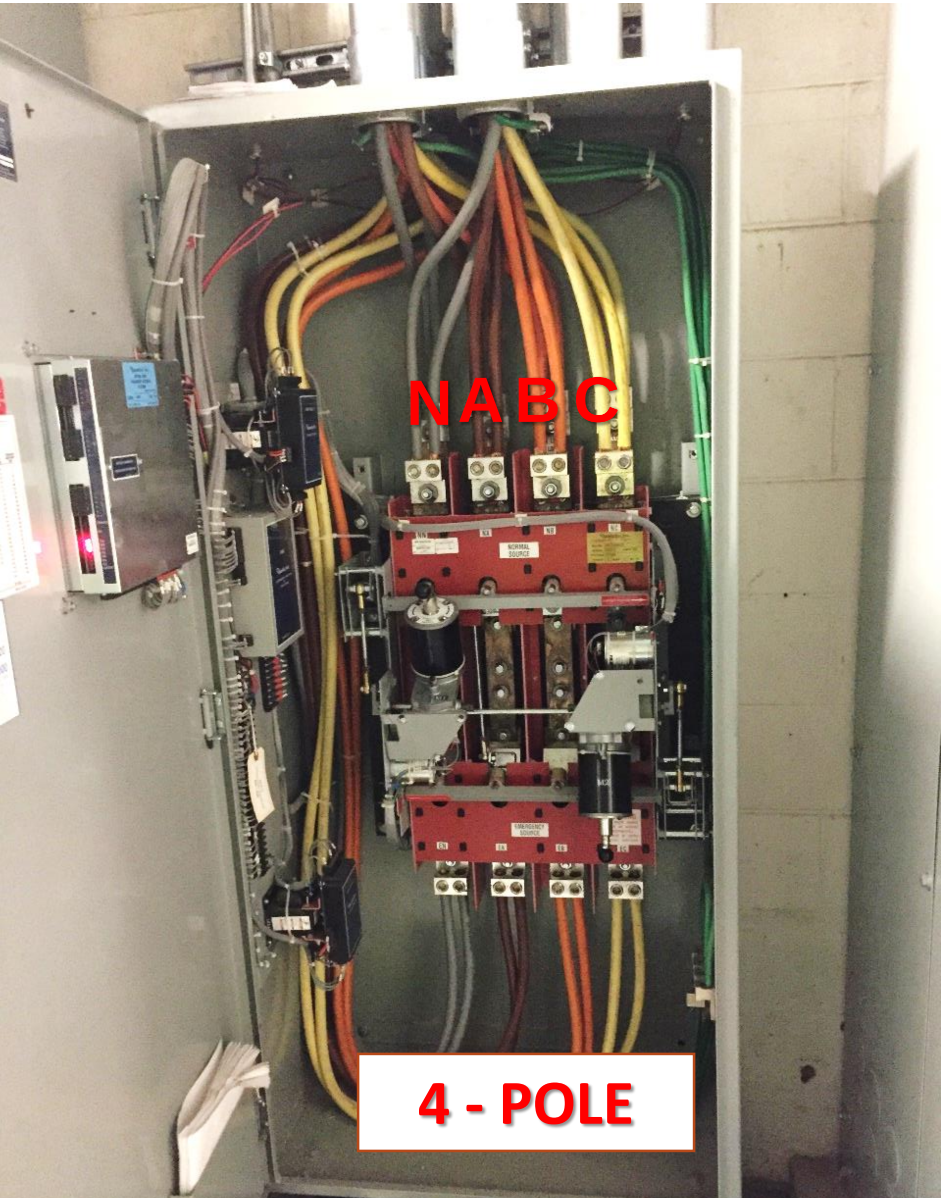
Ex: 4-Pole ATS, with neutral-ground bond at Gen

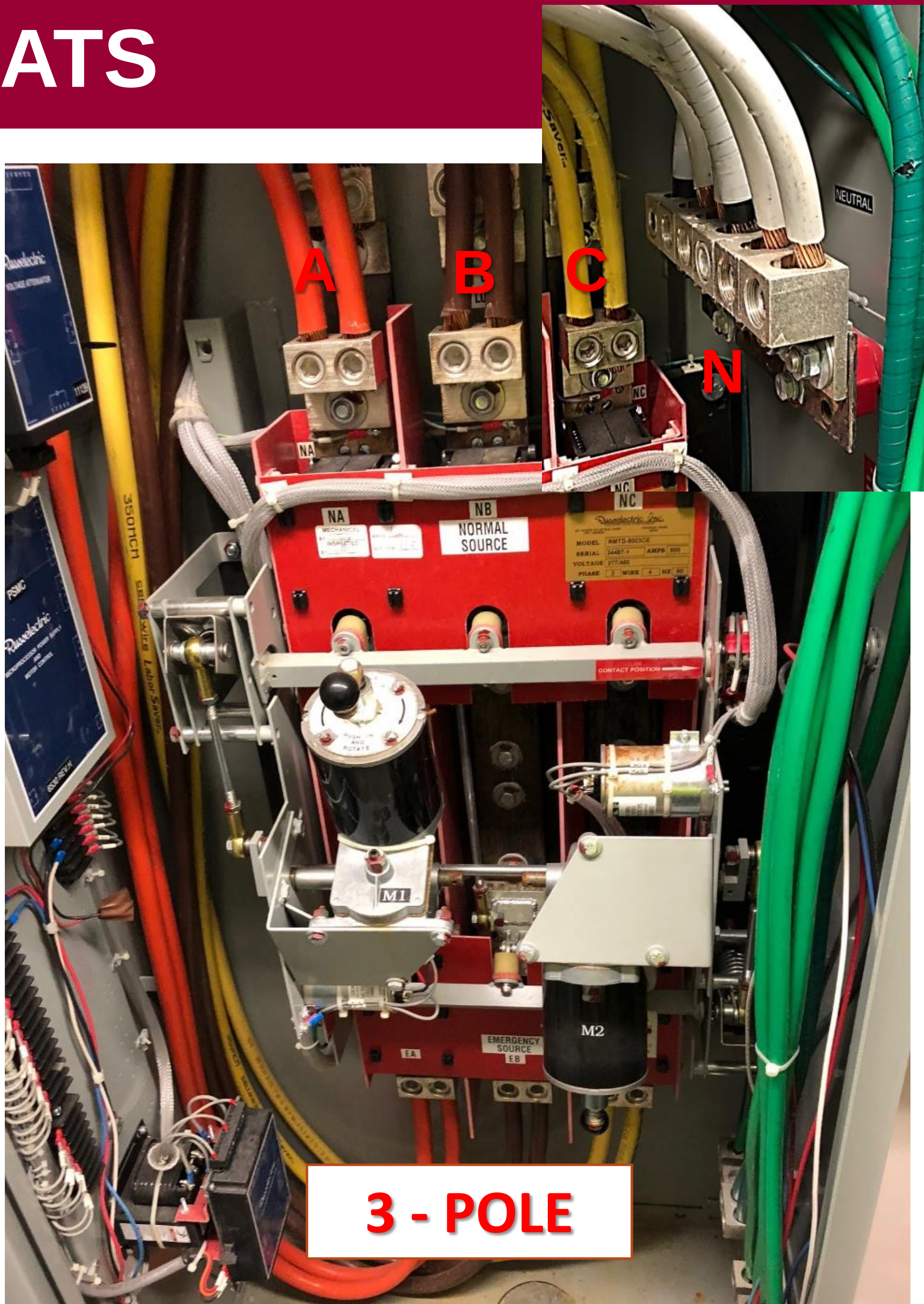
4-Pole ATS: switches A-B-C phases + Neutral

"Separately Derived" Grounding: Neutral + Ground <u>Bonded Together</u> at EPS

4 Pole ATS vs 3 Pole ATS

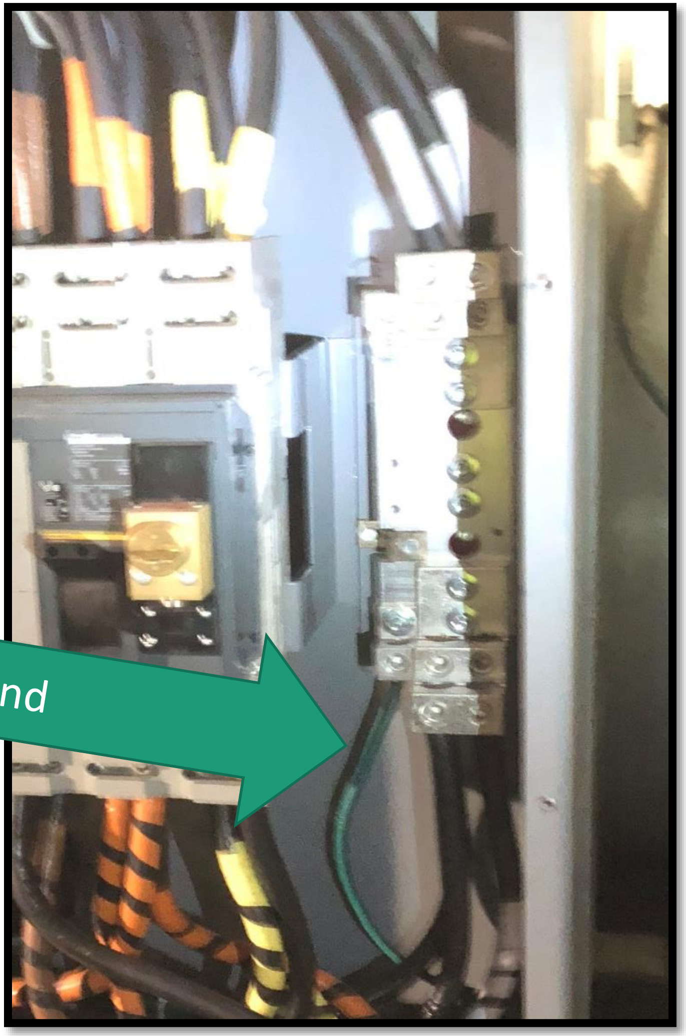
4 Pole ATS vs 3 Pole ATS





Separately Derived vs….

N-G Bond

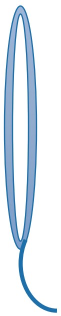


Non-Separately Derived Grounding

Case Study Example: Grounding

Utility Service

N-G BOND



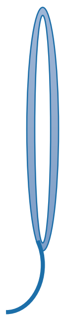
GFP

4 Pole
(switched
neutral)

LOAD

FAULT

Emergency Service (EPS)



N-G BOND

GF

3 Pole
(solid
neutral)

LOAD

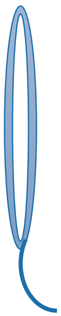
FAULT

Case Study Example: Grounding

Utility Service

Emergency Service (EPS)

N-G BOND



FLOATING NEUTRAL

NO N-G BOND

4 Pole (switched neutral)

3 Pole (solid neutral)

LOAD

LOAD

FAULT

FAULT

Acceptance Phase

Acceptance Phase

What does the CxA Actually Do?

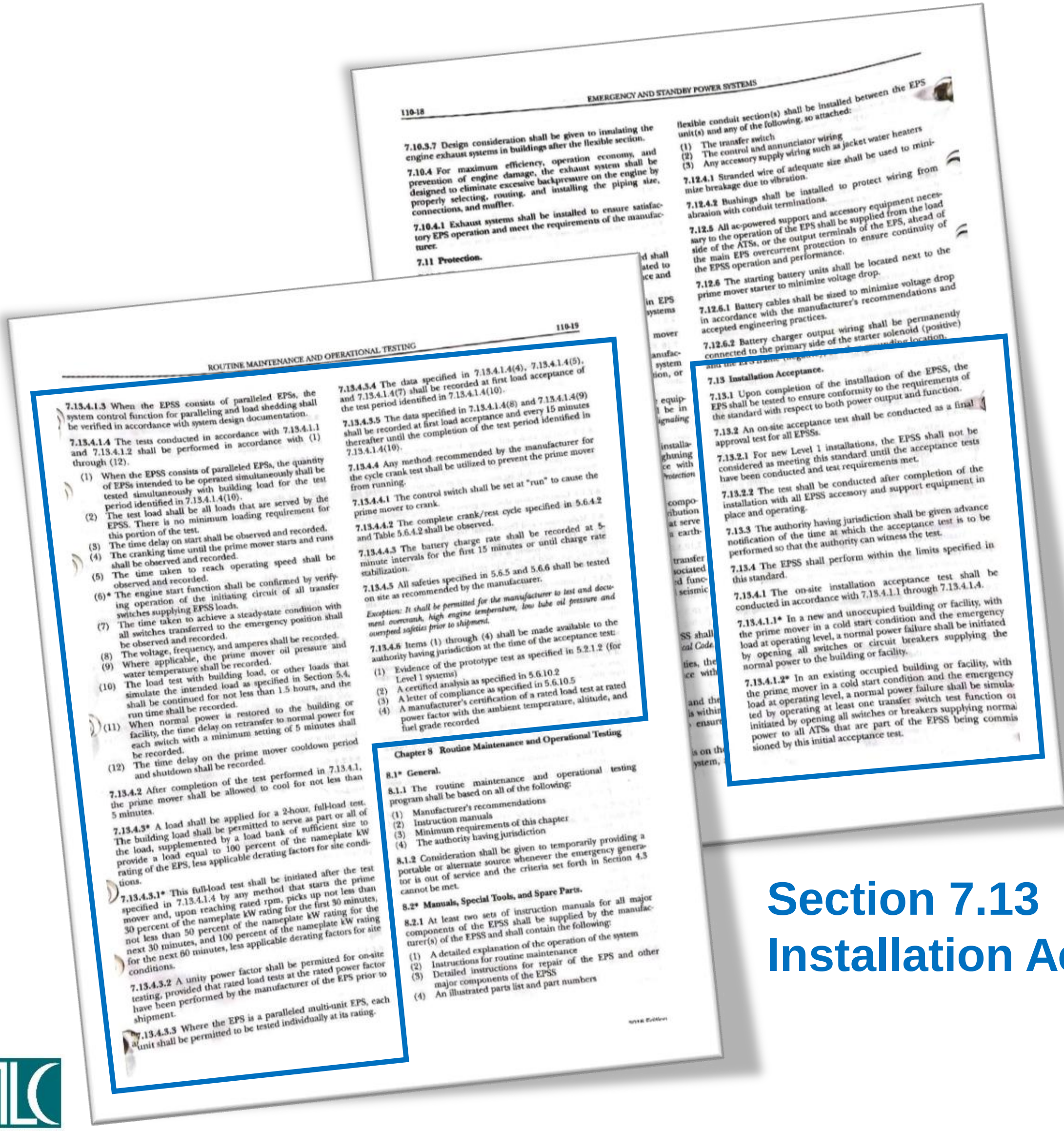
Verify Installation Complete

Verify Pre-Functional Testing is Complete

Integrated Systems Testing!!

Issues Logs

Acceptance Phase



7.13 Installation Acceptance.

7.13.1 Upon completion of the installation of the EPSS, the EPS shall be tested to ensure conformity to the requirements of the standard with respect to both power output and function.

7.13.2 An on-site acceptance test shall be conducted as a final approval test for all EPSSs.

7.13.2.1 For new Level 1 installations, the EPSS shall not be considered as meeting this standard until the acceptance tests have been conducted and test requirements met.

7.13.2.2 The test shall be conducted after completion of the installation with all EPSS accessory and support equipment in place and operating.

7.13.3 The authority having jurisdiction shall be given advance notification of the time at which the acceptance test is to be performed so that the authority can witness the test.

7.13.4 The EPSS shall perform within the limits specified in this standard.

7.13.4.1 The on-site installation acceptance test shall be conducted in accordance with 7.13.4.1.1 through 7.13.4.1.4.

7.13.4.1.1* In a new and unoccupied building or facility, with the prime mover in a cold start condition and the emergency load at operating level, a normal power failure shall be initiated by opening all switches or circuit breakers supplying the normal power to the building or facility.

7.13.4.1.2* In an existing occupied building or facility, with the prime mover in a cold start condition and the emergency load at operating level, a normal power failure shall be simulated by operating at least one transfer switch test function or initiated by opening all switches or breakers supplying normal power to all ATSs that are part of the EPSS being commissioned by this initial acceptance test.

How do I Test the Systems?

NFPA 110

is baseline!

Section 7.13
Installation Acceptance

ENGINEERING FOR ARCHITECTURE

Acceptance Phase

How do I Test the Systems?

Start “Small”:

Fuel Systems

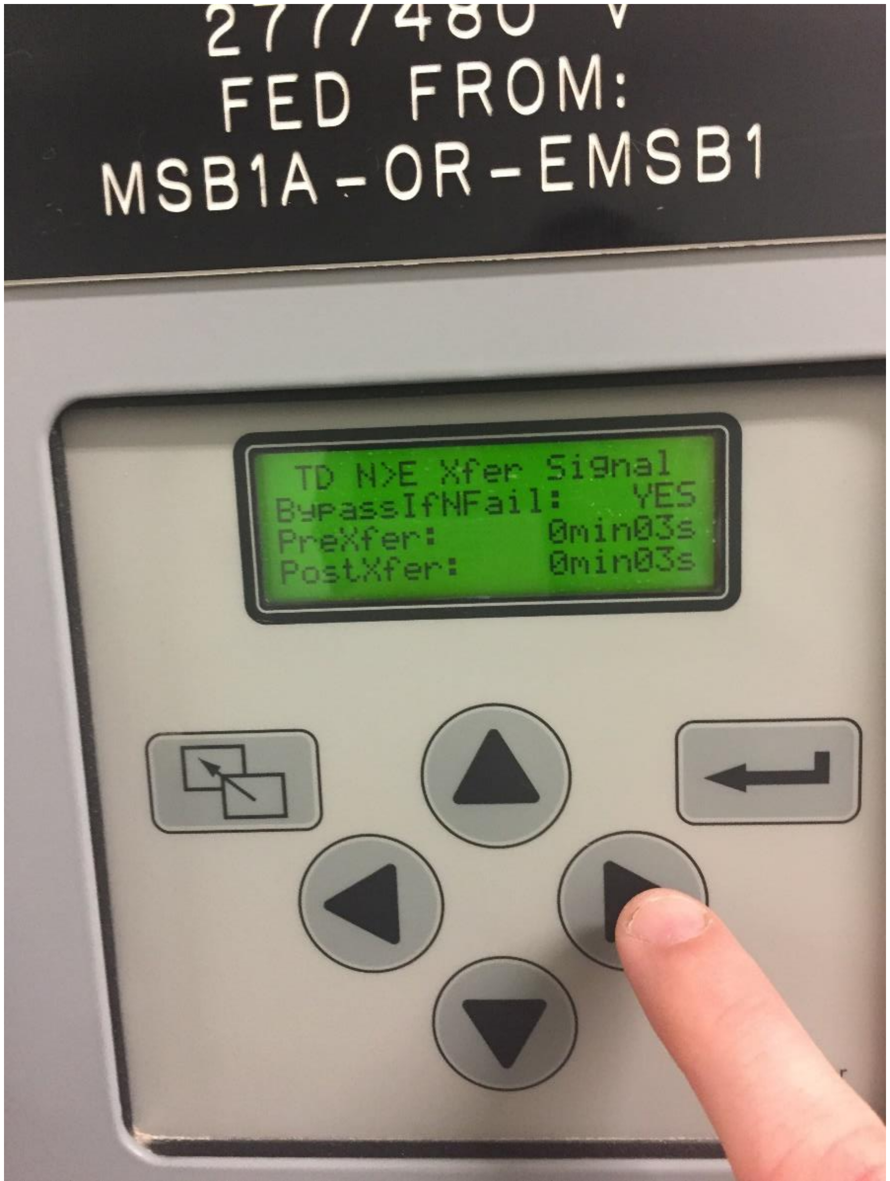
- Main Fuel Tank & Pumps
- Day Tank & Pumps

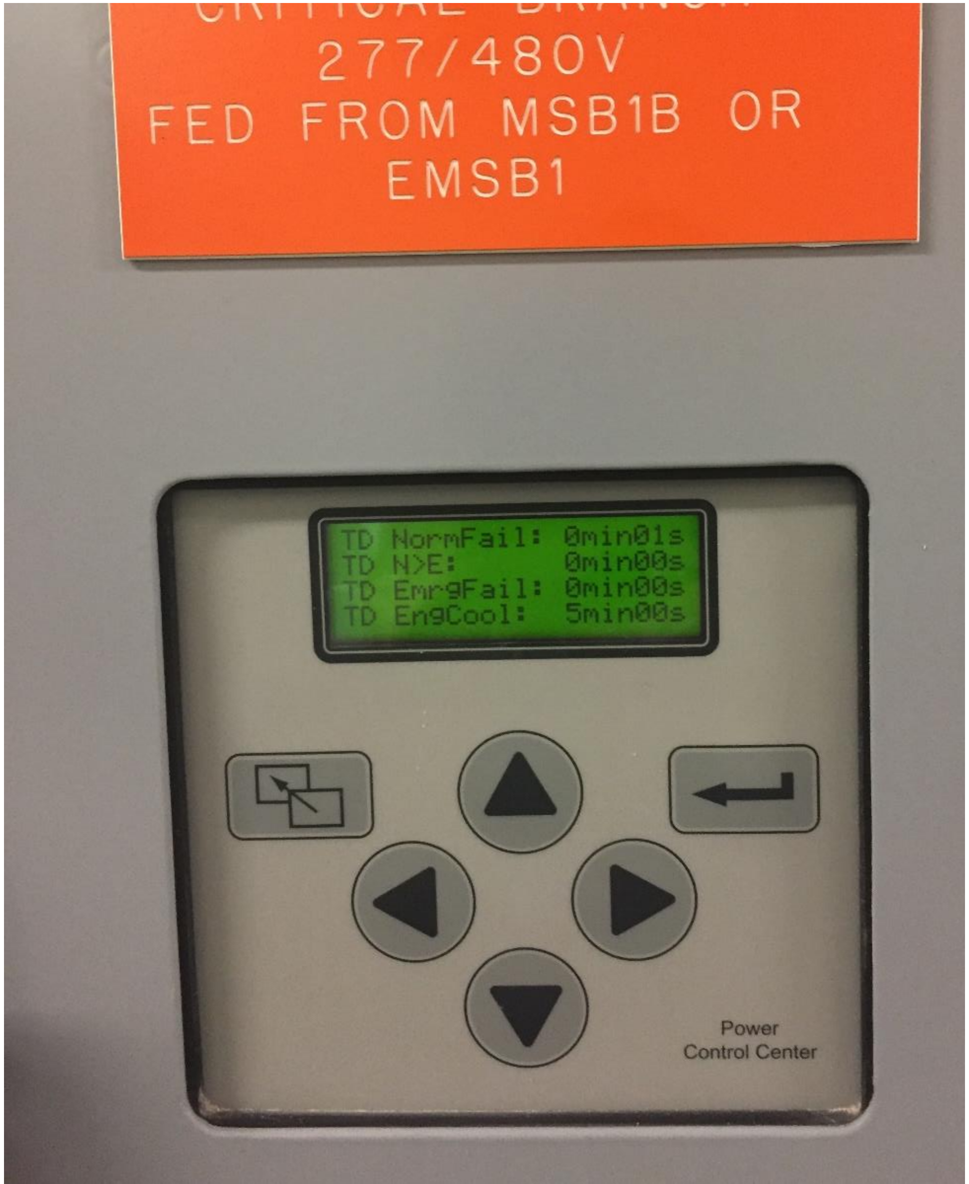
Transfer Switches

- Settings Programmed
- Engine Start Wiring
- Test each ATS Individually

ENGINEERING FOR ARCHITECTURE

Acceptance Phase: Program the ATSs





Acceptance Phase

How do I Test the Systems?

Start Small:

Engine-Generator

Batteries, Charger

Jacket Heater

Load Bank Testing

Sequences of Operation Programed

Load Add / Load Shed

Annunciation & Alarm

Acceptance Phase

How do I Test the Systems?

Go Big!

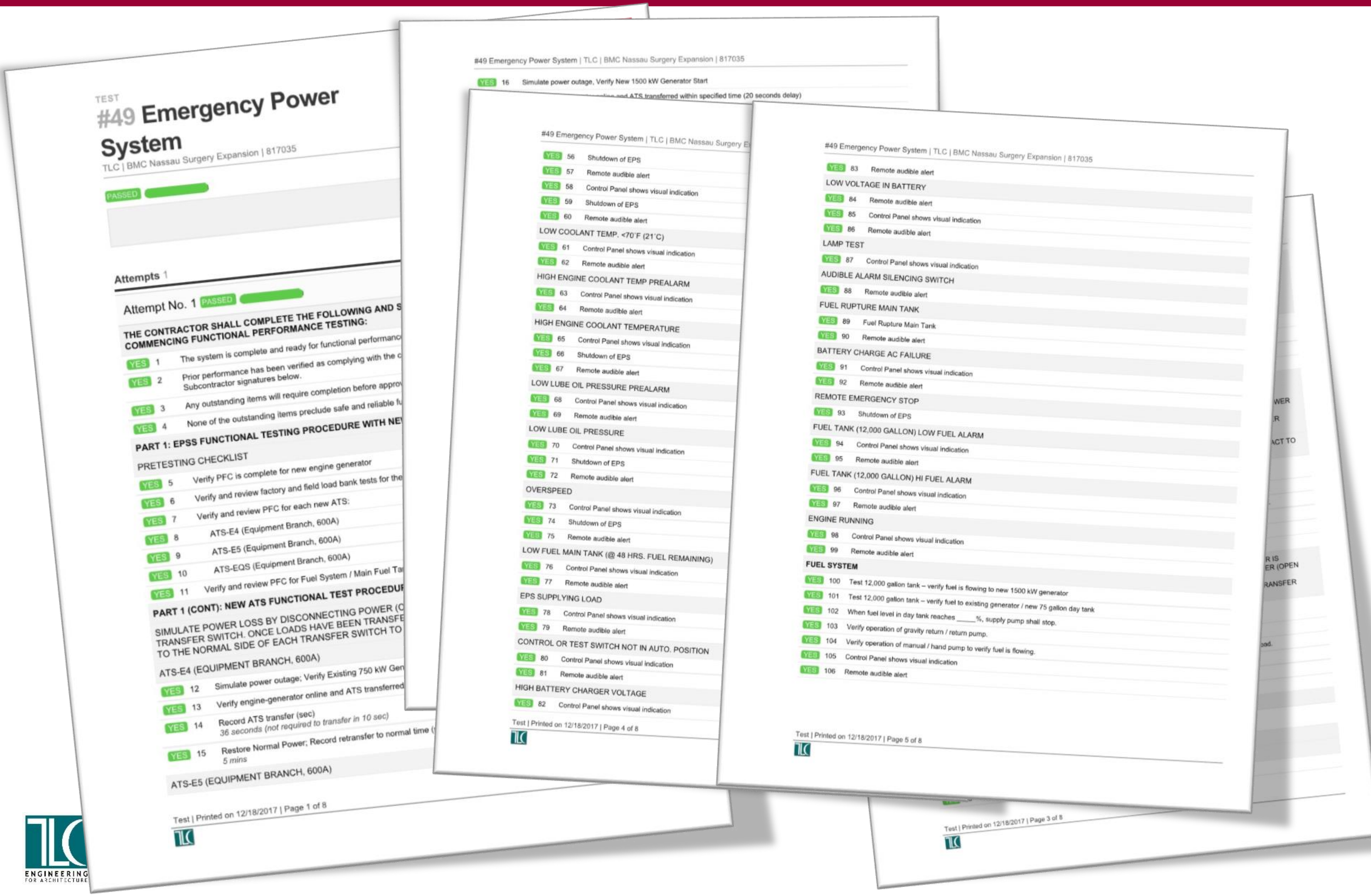
Step 1

Simulate Power Loss

Step 2

See What Happens

Acceptance Phase



TEST

#49 Emergency Power System

TLC | BMC Nassau Surgery Expansion | 817035

PASSED

Attempts 1

Attempt No. 1 PASSED

THE CONTRACTOR SHALL COMPLETE THE FOLLOWING AND S
COMMENCING FUNCTIONAL PERFORMANCE TESTING:

YES 1 The system is complete and ready for functional performanc

YES 2 Prior performance has been verified as complying with the c
Subcontractor signatures below.

YES 3 Any outstanding items will require completion before appro

YES 4 None of the outstanding items preclude safe and reliable fu

PART 1: EPSS FUNCTIONAL TESTING PROCEDURE WITH NE

PRETESTING CHECKLIST

YES 5 Verify PFC is complete for new engine generator

YES 6 Verify and review factory and field load bank tests for the

YES 7 Verify and review PFC for each new ATS:

YES 8 ATS-E4 (Equipment Branch, 600A)

YES 9 ATS-E5 (Equipment Branch, 600A)

YES 10 ATS-EQS (Equipment Branch, 600A)

YES 11 Verify and review PFC for Fuel System / Main Fuel Ta

PART 1 (CONT): NEW ATS FUNCTIONAL TEST PROCEDUR

SIMULATE POWER LOSS BY DISCONNECTING POWER (O
TRANSFER SWITCH. ONCE LOADS HAVE BEEN TRANSFE
TO THE NORMAL SIDE OF EACH TRANSFER SWITCH TO

ATS-E4 (EQUIPMENT BRANCH, 600A)

YES 12 Simulate power outage; Verify Existing 750 kW Gen

YES 13 Verify engine-generator online and ATS transferred

YES 14 Record ATS transfer (sec)
36 seconds (not required to transfer in 10 sec)

YES 15 Restore Normal Power; Record retransfer to normal time (
5 mins

ATS-E5 (EQUIPMENT BRANCH, 600A)

Test | Printed on 12/18/2017 | Page 1 of 8

#49 Emergency Power System | TLC | BMC Nassau Surgery Expansion | 817035

YES 16 Simulate power outage, Verify New 1500 kW Generator Start

#49 Emergency Power System | TLC | BMC Nassau Surgery E

YES 56 Shutdown of EPS

YES 57 Remote audible alert

YES 58 Control Panel shows visual indication

YES 59 Shutdown of EPS

YES 60 Remote audible alert

LOW COOLANT TEMP. <70°F (21°C)

YES 61 Control Panel shows visual indication

YES 62 Remote audible alert

HIGH ENGINE COOLANT TEMP PREALARM

YES 63 Control Panel shows visual indication

YES 64 Remote audible alert

HIGH ENGINE COOLANT TEMPERATURE

YES 65 Control Panel shows visual indication

YES 66 Shutdown of EPS

YES 67 Remote audible alert

LOW LUBE OIL PRESSURE PREALARM

YES 68 Control Panel shows visual indication

YES 69 Remote audible alert

LOW LUBE OIL PRESSURE

YES 70 Control Panel shows visual indication

YES 71 Shutdown of EPS

YES 72 Remote audible alert

OVERSPEED

YES 73 Control Panel shows visual indication

YES 74 Shutdown of EPS

YES 75 Remote audible alert

LOW FUEL MAIN TANK (@ 48 HRS. FUEL REMAINING)

YES 76 Control Panel shows visual indication

YES 77 Remote audible alert

EPS SUPPLYING LOAD

YES 78 Control Panel shows visual indication

YES 79 Remote audible alert

CONTROL OR TEST SWITCH NOT IN AUTO. POSITION

YES 80 Control Panel shows visual indication

YES 81 Remote audible alert

HIGH BATTERY CHARGER VOLTAGE

YES 82 Control Panel shows visual indication

Test | Printed on 12/18/2017 | Page 4 of 8

#49 Emergency Power System | TLC | BMC Nassau Surgery Expansion | 817035

YES 83 Remote audible alert

LOW VOLTAGE IN BATTERY

YES 84 Remote audible alert

YES 85 Control Panel shows visual indication

YES 86 Remote audible alert

LAMP TEST

YES 87 Control Panel shows visual indication

AUDIBLE ALARM SILENCING SWITCH

YES 88 Remote audible alert

FUEL RUPTURE MAIN TANK

YES 89 Fuel Rupture Main Tank

YES 90 Remote audible alert

BATTERY CHARGE AC FAILURE

YES 91 Control Panel shows visual indication

YES 92 Remote audible alert

REMOTE EMERGENCY STOP

YES 93 Shutdown of EPS

FUEL TANK (12,000 GALLON) LOW FUEL ALARM

YES 94 Control Panel shows visual indication

YES 95 Remote audible alert

FUEL TANK (12,000 GALLON) HI FUEL ALARM

YES 96 Control Panel shows visual indication

YES 97 Remote audible alert

ENGINE RUNNING

YES 98 Control Panel shows visual indication

YES 99 Remote audible alert

FUEL SYSTEM

YES 100 Test 12,000 gallon tank – verify fuel is flowing to new 1500 kW generator

YES 101 Test 12,000 gallon tank – verify fuel to existing generator / new 75 gallon day tank

YES 102 When fuel level in day tank reaches ____%, supply pump shall stop.

YES 103 Verify operation of gravity return / return pump.

YES 104 Verify operation of manual / hand pump to verify fuel is flowing.

YES 105 Control Panel shows visual indication

YES 106 Remote audible alert

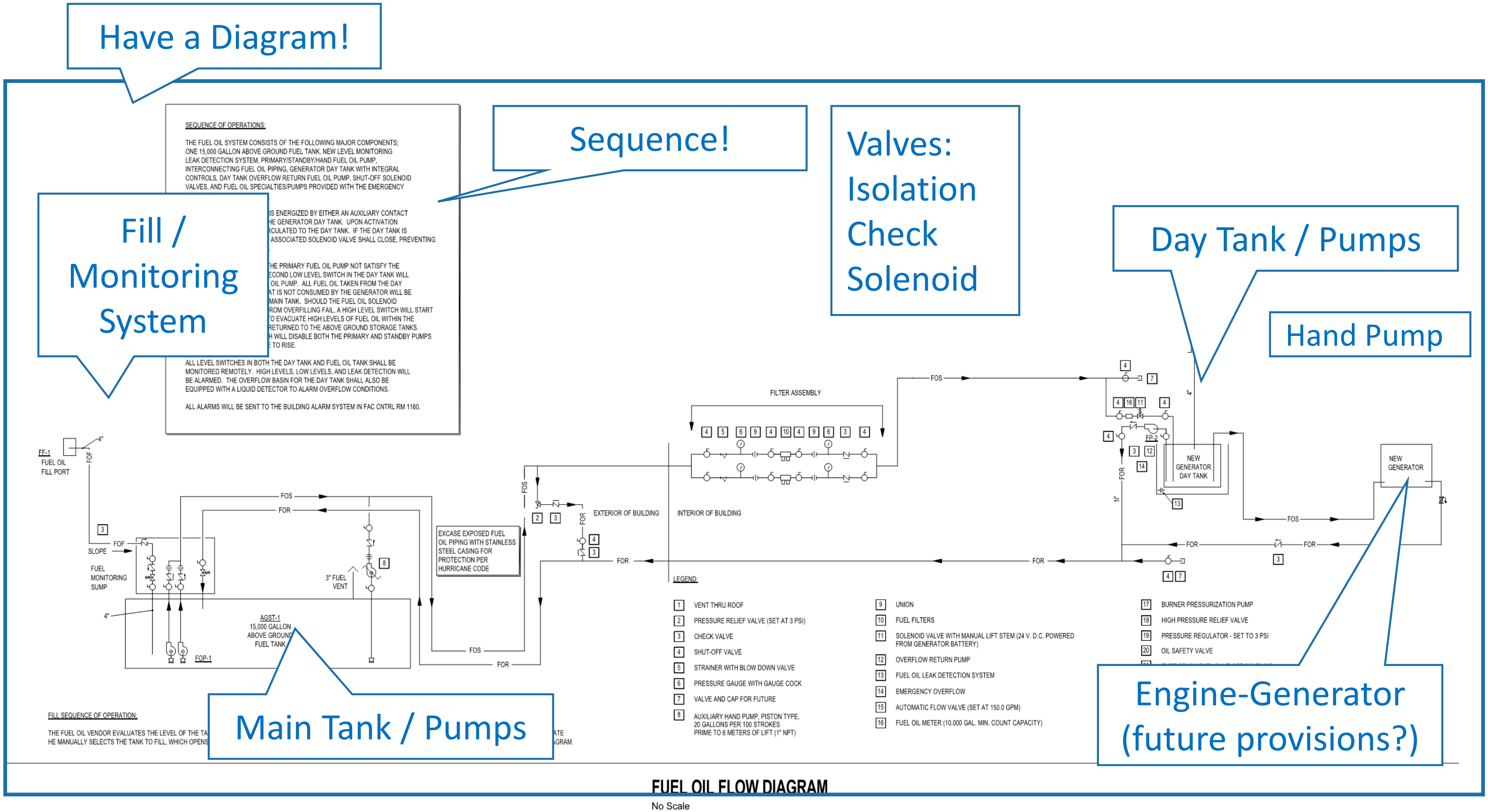
Test | Printed on 12/18/2017 | Page 5 of 8

Test | Printed on 12/18/2017 | Page 3 of 8

Case Study Example: Fuel Systems

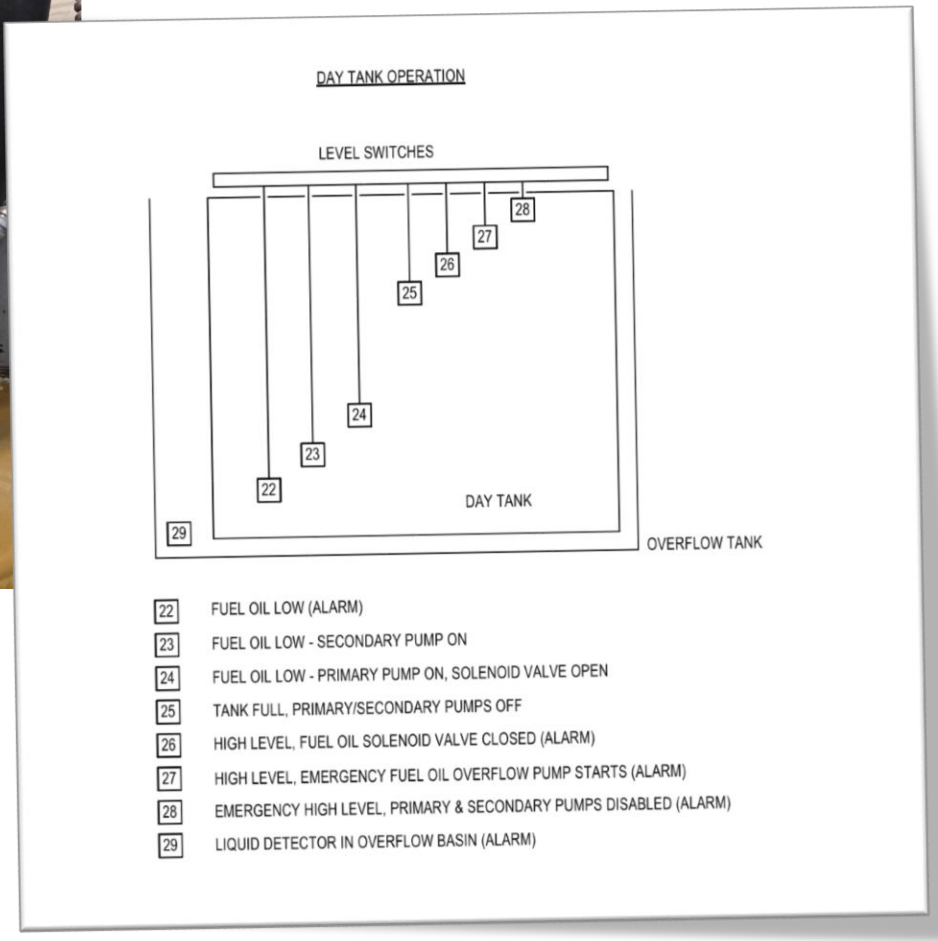
Case Study Example: Fuel Systems

Components of a Fuel System Diagram:



Case Study Example: Fuel System

Case Study Example: Fuel System

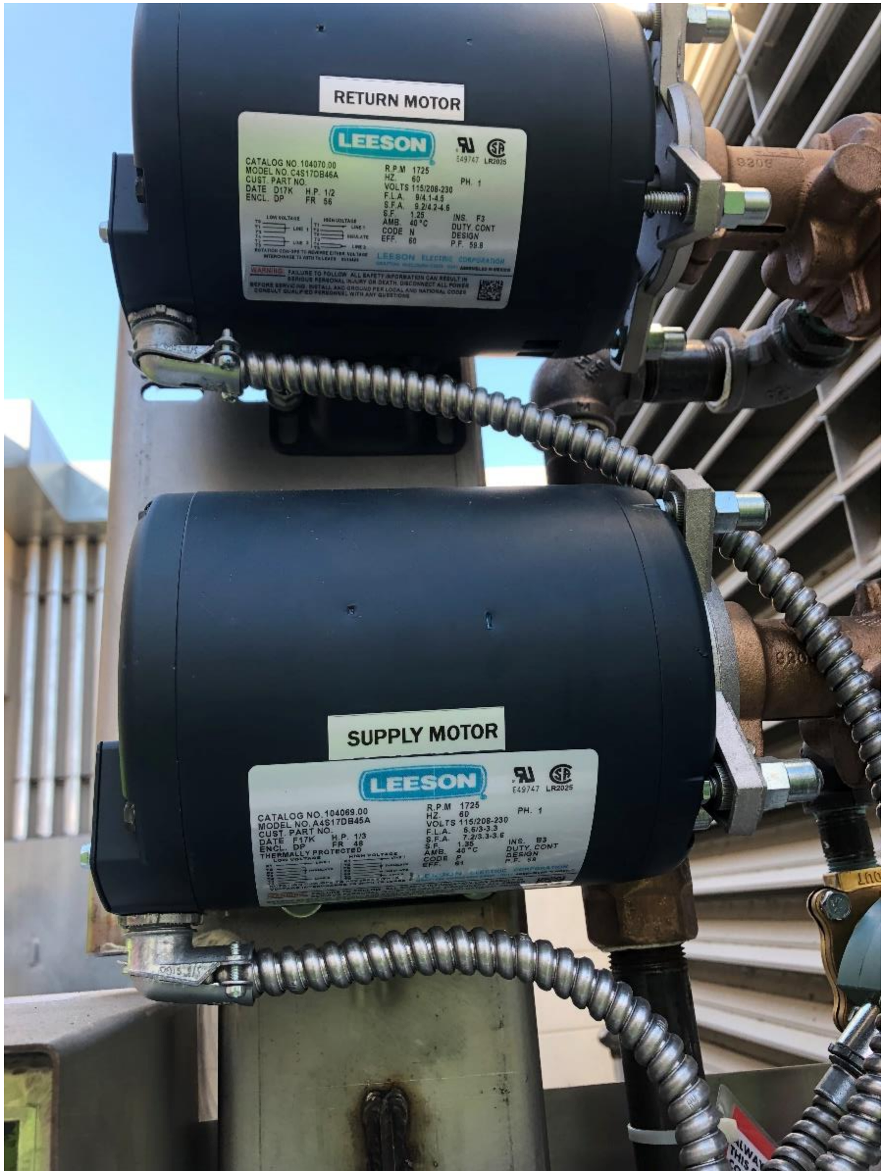


Q: At what level should low / high level alarms be set?

A: Wherever the EOR says to set them.

TLC ENGINEERING FOR ARCHITECTURE

Case Study Example: Fuel System



Post-Occupancy Phase

It’s not over

until its over….

Post-Occupancy Phase

What does the CxA Actually Do?

All Issues Resolved?

Preliminary Report

Systems Manuals

O&M Manuals

Training

Final Report

Post-Occupancy Phase

Who's the Owner?

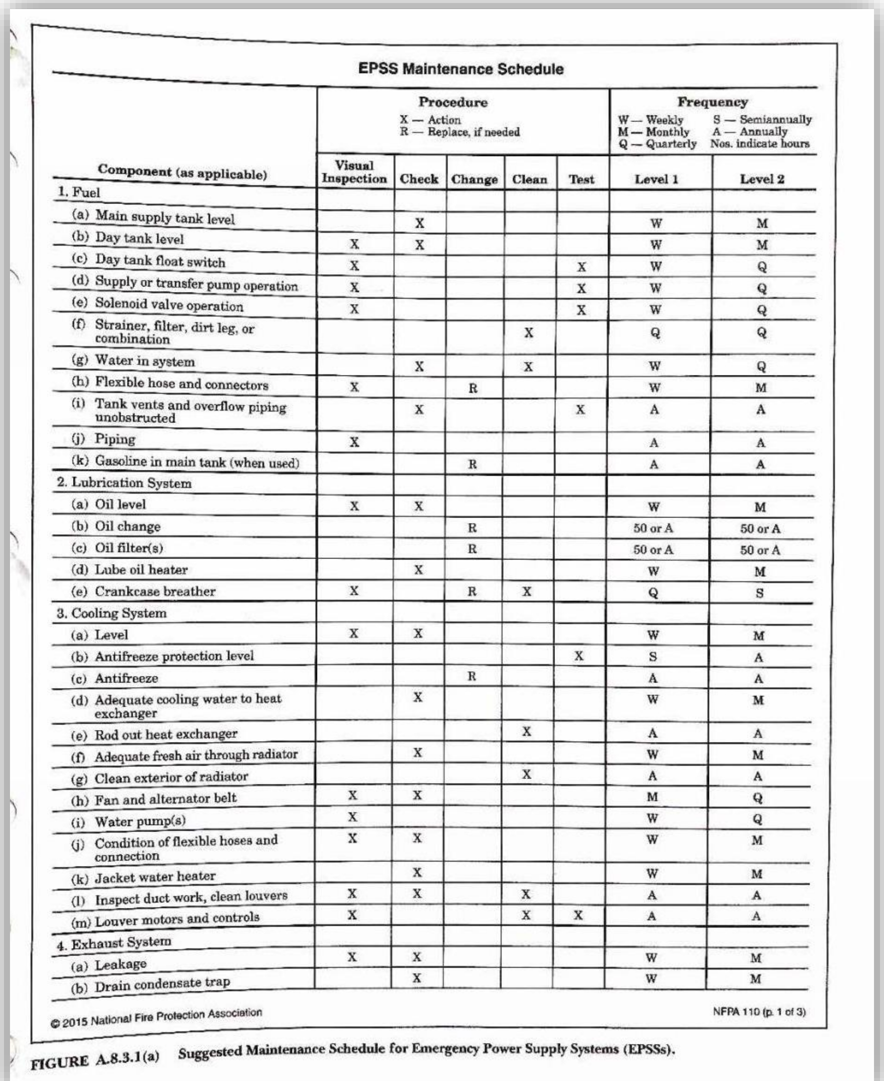
- Facility operations and maintenance staff
- Often overlooked

Interviews and dialogue with operations staff are critical!

- During design
- During functional testing

ENGINEERING FOR ARCHITECTURE

Ongoing Testing: NFPA 110



EPSS Maintenance Schedule

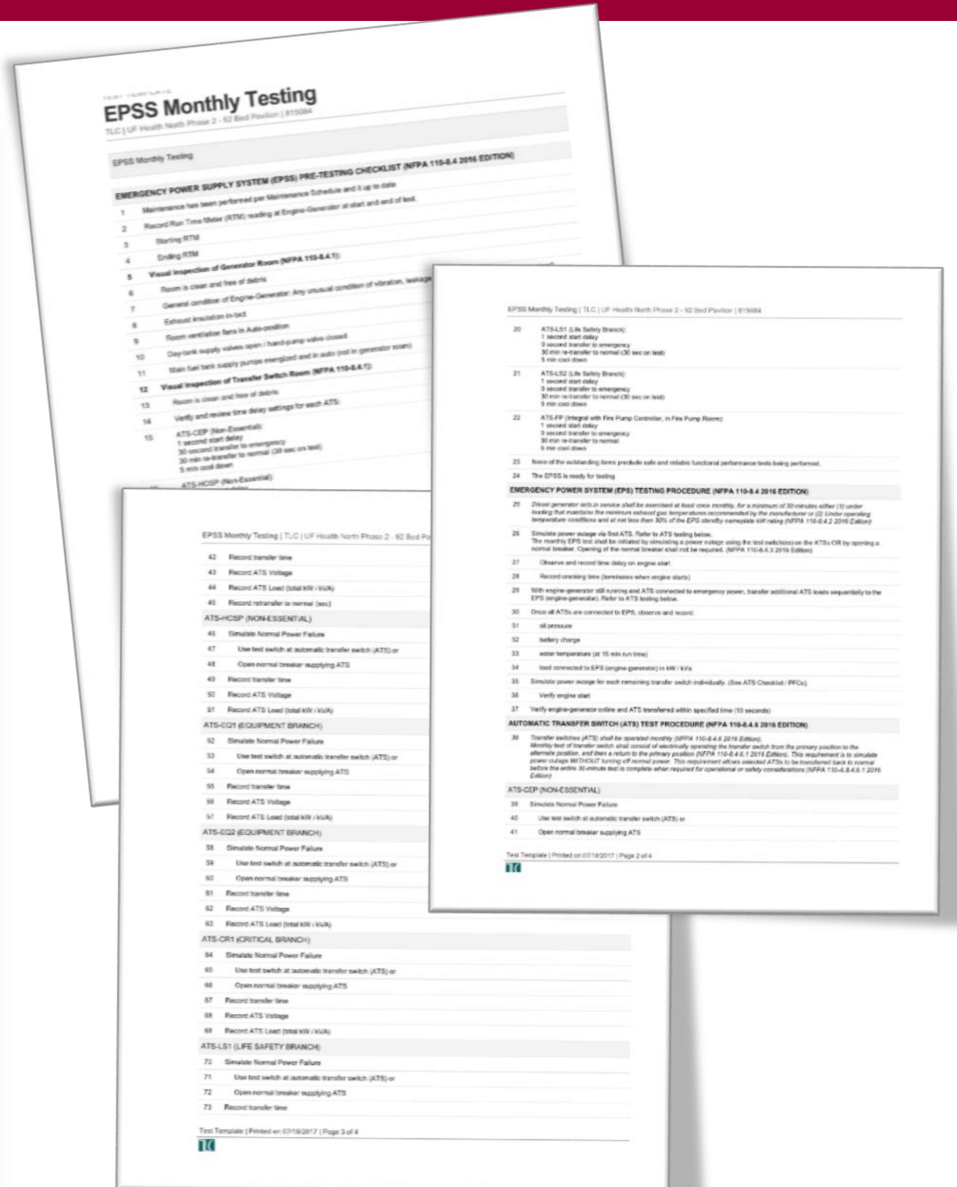
Component (as applicable)	Procedure: Visual Inspection	Procedure: Check	Procedure: Change	Procedure: Clean	Procedure: Test	Frequency: Level 1	Frequency: Level 2
1. Fuel							
(a) Main supply tank level		X				W	M
(b) Day tank level	X	X				W	M
(c) Day tank float switch	X				X	W	Q
(d) Supply or transfer pump operation	X				X	W	Q
(e) Solenoid valve operation	X				X	W	Q
(f) Strainer, filter, dirt leg, or combination				X		Q	Q
(g) Water in system		X		X		W	Q
(h) Flexible hose and connectors	X		R			W	M
(i) Tank vents and overflow piping unobstructed		X			X	A	A
(j) Piping	X					A	A
(k) Gasoline in main tank (when used)			R			A	A
2. Lubrication System							
(a) Oil level	X	X				W	M
(b) Oil change			R			50 or A	50 or A
(c) Oil filter(s)			R			50 or A	50 or A
(d) Lube oil heater		X				W	M
(e) Crankcase breather	X		R	X		Q	S
3. Cooling System							
(a) Level	X	X				W	M
(b) Antifreeze protection level					X	S	A
(c) Antifreeze			R			A	A
(d) Adequate cooling water to heat exchanger		X				W	M
(e) Rod out heat exchanger				X		A	A
(f) Adequate fresh air through radiator		X				W	M
(g) Clean exterior of radiator				X		A	A
(h) Fan and alternator belt	X	X				M	Q
(i) Water pump(s)	X					W	Q
(j) Condition of flexible hoses and connection	X	X				W	M
(k) Jacket water heater		X				W	M
(l) Inspect duct work, clean louvers	X	X		X		A	A
(m) Louver motors and controls	X			X	X	A	A
4. Exhaust System							
(a) Leakage	X	X				W	M
(b) Drain condensate trap		X				W	M

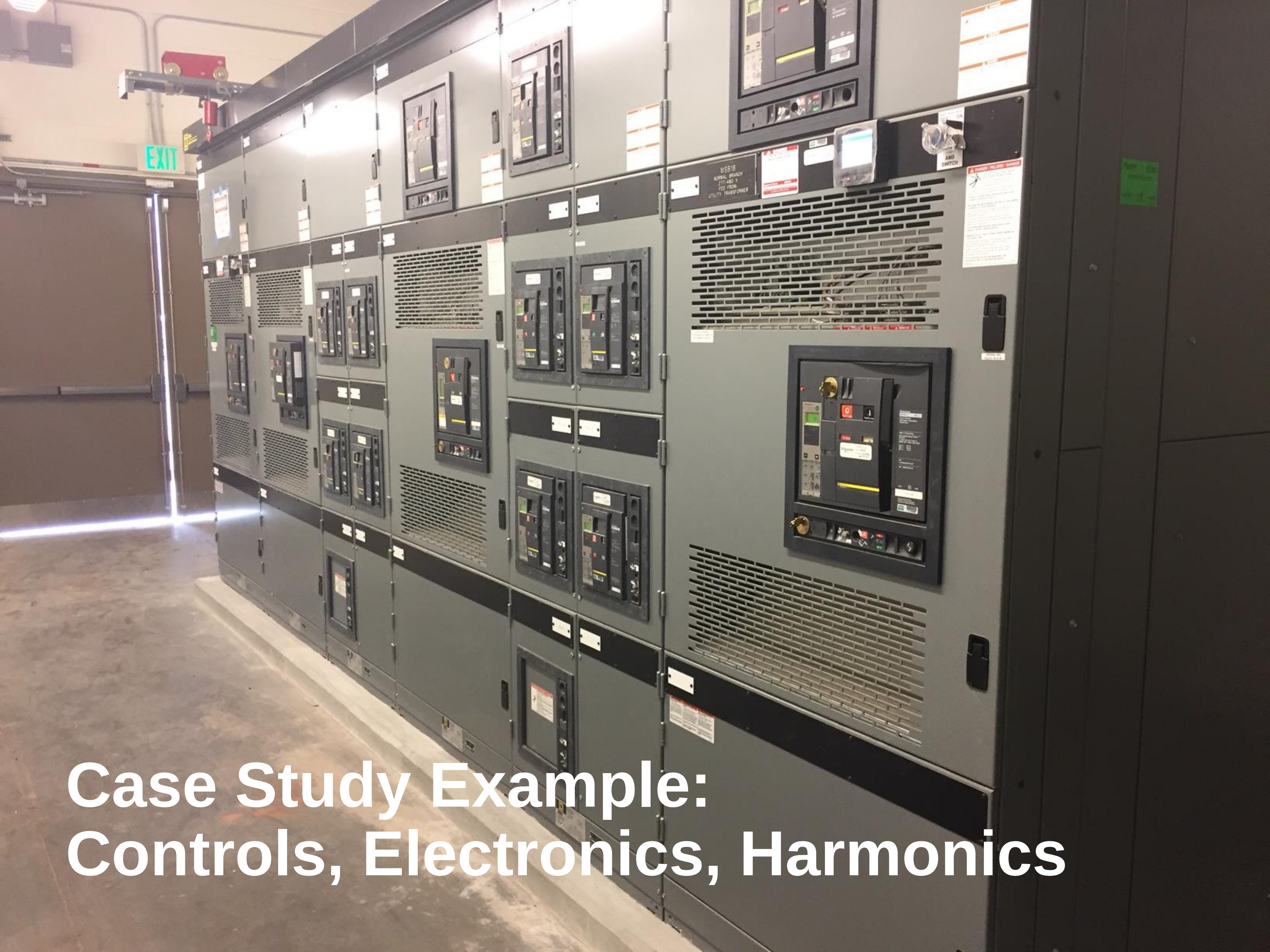
Procedure: X — Action; R — Replace, if needed

Frequency: W — Weekly; M — Monthly; Q — Quarterly; S — Semiannually; A — Annually; Nos. indicate hours

NFPA 110 (p. 1 of 3)

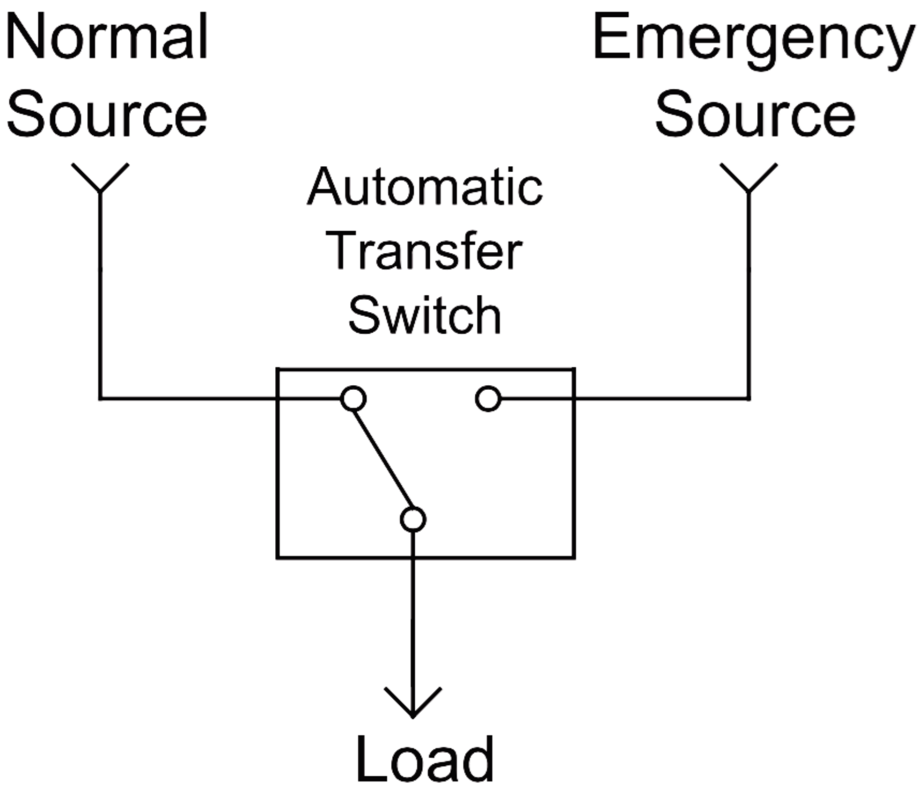
FIGURE A.8.3.1(a) Suggested Maintenance Schedule for Emergency Power Supply Systems (EPSSs).





Case Study Example:
Controls, Electronics, Harmonics

What Happens When ATSs Transfer?



WE LOSE POWER

Case Study Example: Controls

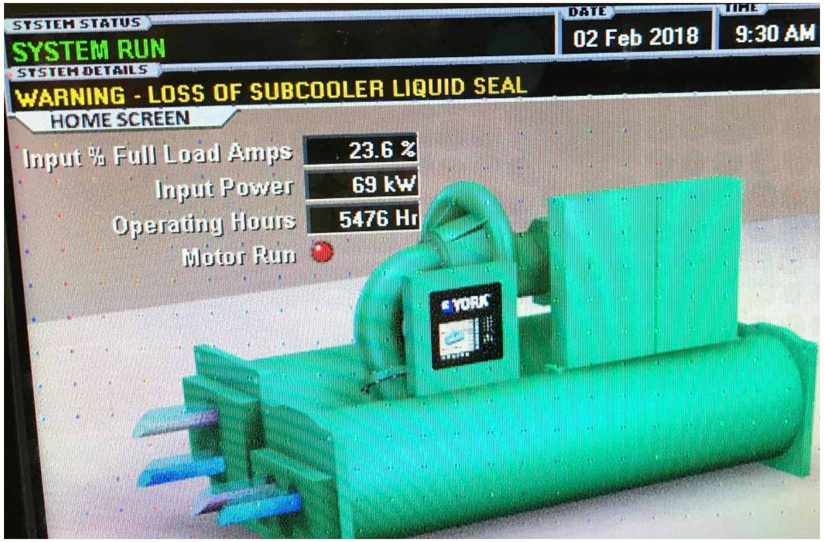
ATS Transfer
(or re-transfer)

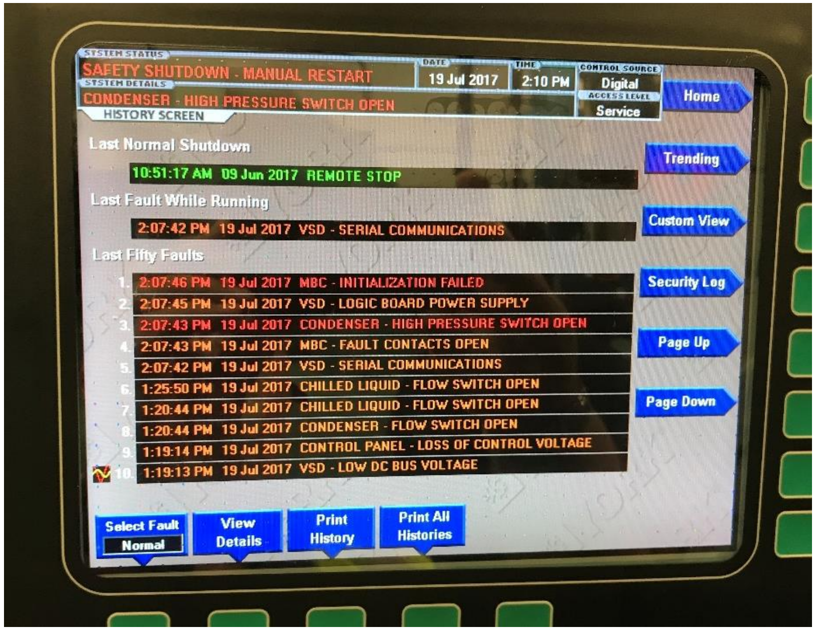
Controls Failure

Loads dependent on electronic control systems…

- HVAC
- Chillers
- Elevators

…. May fail to come back online after transfer





Case Study Example: UPS & Harmonics

ATS Transfer
(or re-transfer)

UPS Sensitivity
Sensitive Electronics
Controllers

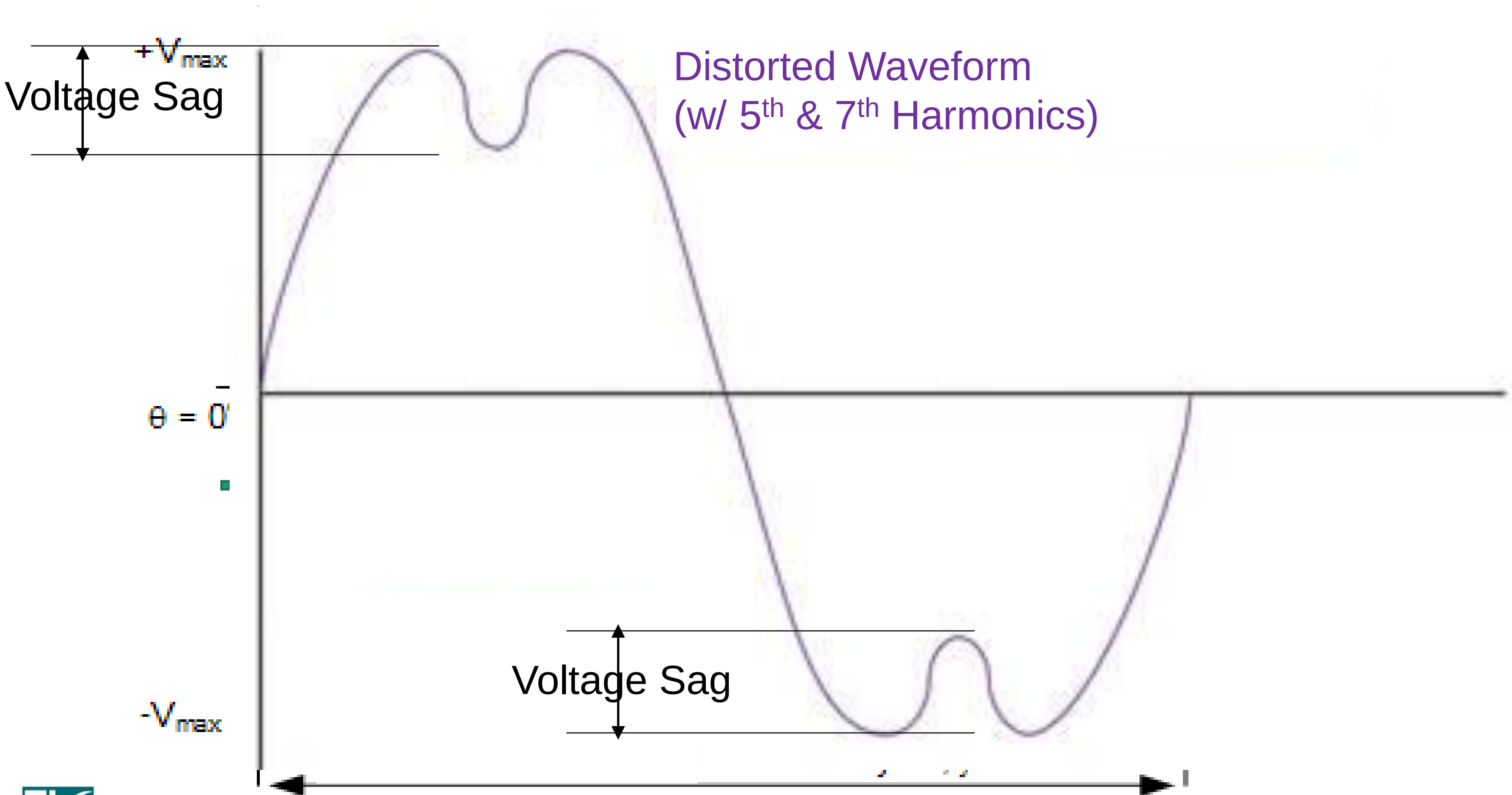
790 HP VSD OPERATION INPUT CURRENT HARMONICS- 7/19/99

Base Unit - Input Current Harmonics, 100% Load	
Harmonic	Ave. Three Phase Input Current (RMS)
1	789.00
2	0.71
3	10.81
4	2.05
5	172.63
6	0.55
7	100.36
8	0.71
9	4.18
10	0.63
11	53.18
12	0.16
13	38.19
14	0.24
15	[illegible]

Unit w/Filter- Input Current Harmonics, 100% Load	
Harmonic	Ave. Three Phase Input Current (RMS)
1	789.00
2	4.02
3	1.74
4	2.37
5	4.73
6	1.34
7	12.23
8	0.47
9	1.34
10	0.95
11	9.63
12	0.39
13	8.76
14	0.32
15	[illegible]

Case Study Example: UPS & Harmonics

https://www.csemag.com/single-article/avoiding-harmonics-in-hvac-and-electrical-systems/6902cb50dd93f69a07cd4005fba4288f.html



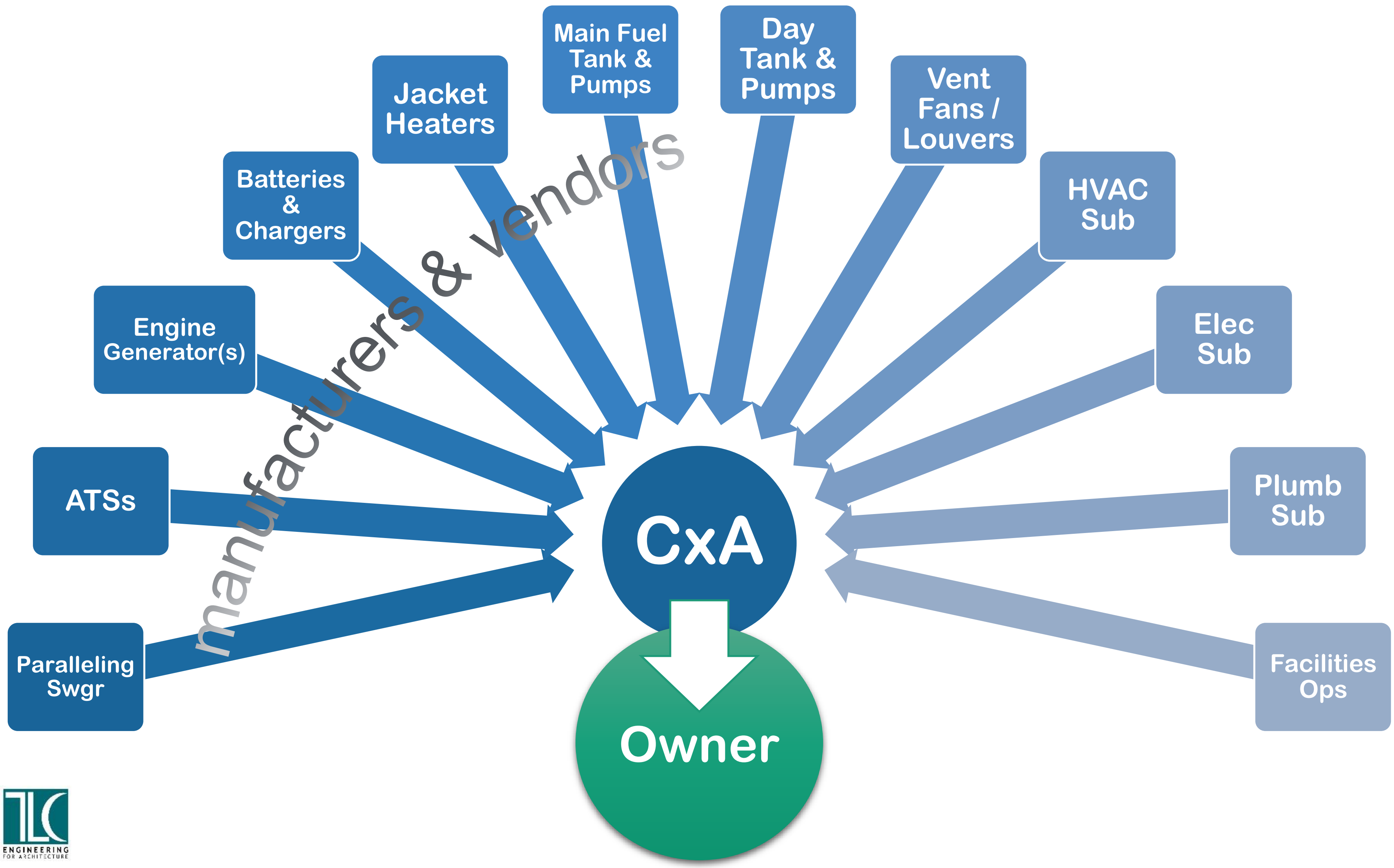
Case Study Example: UPS & Harmonics

(Sensitive) Electronics

HATE

Harmonics

It Takes a Team!

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