Managing the Whole Building Shutdown Test

Karl Stum
Summit Building Engineering

Walt Ackermann
Summit Building Engineering

Synopsis

Our experience has shown that the operations staff, designer and contractor often have very different understandings on what should actually happen during a power outage. Confirming these expectations through a formal test is critical to ensure that life safety, product and equipment protection, comfort and O&M staff convenience are not compromised during a power outage. Documenting the expectations for response to and from street power through an emergency power response matrix is critical for the test to be performed that confirms these expectations. The test can be successful if a detailed plan is developed that includes an overview and objectives, a list of the test prerequisites, and the role each player will have. The plan should also give a general chronological list of what will happen on test day and a specific test schedule for the events. Equipment components should be tested prior to the formal power outage test. Staggering restarts of equipment by specified time delays can be verified by careful planning and sufficient witnesses or special temporary alarms set up to record the startup of equipment.

About the Authors

Karl Stum is a registered professional engineer and has more than 14 years of experience in commissioning. He specializes in large, complex facilities and in commissioning controls. Mr. Stum is a past recipient of the Benner Award and is a frequent speaker at NCBC and ASHRAE. He is a principal with Summit Building Engineering in Vancouver, Wash.

Walt Ackermann is a mechanical engineer with background in manufacturing, design, and building controls. He has worked as a building automation system programmer and integrator on several LEED® projects. Mr. Ackerman is currently working as a commissioning authority on a variety of facilities, including labs, schools and office buildings, and the first LEED-Platinum building in Washington, D.C.

What is a Whole Building Shutdown Test?

Description

The whole building shutdown test does not test the generator functions. That test is completed sometime prior to the shutdown test. The whole building shutdown refers to a test where, once all equipment and systems powered by electricity are complete, the electrical power to the *entire building* is shut off imitating a street power outage. The electrical generator is allowed to start normally and then later normal "street" power is restored. This is much more than a test of the generator. It is a test of the way that every piece of equipment reacts to such an event—does it restart with the generator automatically? Is it on an uninterruptible power supply (UPS) and ride through the eight seconds it takes for the generator to start? Once street power is restored does equipment not on emergency power require a manual reset to start, or does it automatically restart? Are required time delays to restart accomplished? Do the position of dampers and actuators remain or return to specified states during the loss of power? Are there any adverse interactions with the building comfort and process systems during the event? These questions and more need to be verified for each piece of equipment during the test.

Why Is the Test Important?

Equipment loss of power can result in compromised

- life safety
- product and equipment protection
- comfort
- O&M staff convenience

For example, in one laboratory project when the power was lost for a few minutes at the beginning of a weekend, the chiller went and remained off line as expected (it was not on generator power). However, the building automation system (BAS) continued to send the chiller a signal to start, and of course it didn't. After one minute, the BAS deemed the chillers in fault and commanded the chiller off. The second chiller was called for, and the same thing happened. Operations staff did not get any alarms, and the chillers remained off all weekend. Dehumidification needed for a critical piece of lab equipment was not accomplished without chilled water, and a very expensive piece of equipment was damaged and had to be replaced.

On another laboratory project, when street power was lost the air handlers drop off line, as expected, but the lab exhaust fans remained on, but at a reduced speed, as expected. Testing showed the fan speed to be too high, causing excessive pressure required to open egress doors.

On a project with large air handlers, not all dampers had end switches providing damper position feedback, so when power was restored, fans ramped up with no delay and over-pressurized the duct before the dampers were sufficiently open.

On a facility currently being commissioned, the contractor insisted on partially testing by only disconnecting specific panels and circuits and then running the generator. Trying not to incur lost schedule time, they never did an actual whole building shutdown prior to the official test, resulting in many unexpected issues and test failure when the actual test was conducted. This cost several days of rework, BAS programming and rewire, and ultimately a very disappointed customer.

On multiple projects we have seen the equipment on emergency power, but their BAS control panels not on emergency power, resulting in the equipment unable to operate during the power outage. On other projects the BAS controllers were on emergency power circuits, but the controllers all went off-line during the eight seconds between loss of street power and generator power being injected. Upon receiving generator power, all the controllers simultaneously came on line and started polling the BAS network, causing severe network bog down and erratic equipment operation, particularly for equipment that was supposed to be staged back on in specific order and time delay. (Simply putting small batteries or UPS in each control panel solved this problem.)

Frequently, the problem is not whether the equipment is on emergency power or not, but that once it goes off-line from loss of power, it doesn't start back up again upon street power restoration without a manual reset at the equipment or at the BAS workstation. This may violate the specifications or at minimum be a big nuisance to operations staff who may not be on site, and could cause any of the problems listed above.

Our experience has shown that the operations staff, designer and contractor often have very different understandings on what should actually happen during a power outage. Building automation system communications during this type of event are often not well understood. This test can be very problematic and result in extra effort by the contractors, requests for information to the design team, change orders and time delays if not specified well, if there is not a response matrix agreed upon, and if the test is not managed well.

Preparing for the Test

Emergency Power Response Matrix

The heart of the preparing for the test is to generate a comprehensive emergency power response matrix. This matrix lists all equipment that uses electrical power, regardless of whether it is on emergency power (EP) or not. Be sure to include any data network devices in the UPS/EP circuitry such as Ethernet switches (hubs) and serial communication repeaters, especially if the BAS is not included on the building LAN.

For each piece of equipment responses to the following are shown in the matrix:

- Is it on EP?
- Is it on a UPS?
- How does it transition from street power to EP (auto or manual reset), or is it just a breaker with no reset required?
- Are there any timing or delays in the restart?
- What is the status of dampers and actuators during the event?

- Is there any special mode that the equipment goes to during EP?

These questions can be answered in detail in the matrix through using a code in the matrix cells. The following is a sample key:

Auto local restart. The equipment is controlled simply by a disconnect. With loss of power the equipment will go off and will immediately start upon restoration of normal or emergency power.

Auto BAS or other controller restart. BAS or other controller (when noted) will restart the equipment upon restoration of normal or emergency power without the need for operator action.

Continuous operation. Equipment is on a UPS, battery or capacitor backup and will remain online for a short time, until EP is on, when on E-power.

Parking structure is not on E-power. UPS power powers equipment to generator and back to normal power without power interruption.

Manual BAS restart. Upon restoration of normal or EP, a reset and/or start sequence in BAS by operator is required.

Emergency power. On the emergency generator circuit. The equipment is on the emergency generator circuit & will have power restored within 8-10 seconds after normal power loss.

Manual local restart. One way action (magnetic or electric hold that needs to be reset manually).

Normal only. The equipment is not on emergency or battery backup and will shut off and remain off upon loss of normal (street) power.

Ride thru from E-power to normal. Running machinery and controllers ride through the transfer from emergency power to normal power without a noticeable loss of power and control.

A column for special sequence or other notes and a column for the information source (specs, drawings, contractor, designer, RFI, etc).

Getting the entire matrix filled in and all the questions answered requires first, a single champion willing to push it through, and then significant effort, cooperation and participation from multiple trades and the design team. Electrical, mechanical, controls, plumbing, fire protection, security, data and communications all need to provide input. One method we've used for generating this matrix is for the commissioning authority to develop the matrix format and then make the first pass at filling in the cells. The source of information is the electrical panel schedule showing all the panels and equipment on emergency power, the specifications and the sequences of operation. The commissioning authority then coordinates obtaining data for areas they have questions about by distributing the partially filled in matrix to the subcontractors and design team. This is often a difficult task. Without exception this process has resulted in formal requests for information from the contractors to the design team and often change orders, as things are clarified and made consistent with the project requirements. The completed matrix is distributed to the sub contractors with the note that every item in this matrix will be tested, and they are responsible to make it happen the way it is on the matrix.

Staggered Starts. When equipment is required to have staggered delays between equipment startup once generator power is online and when going back onto street power for equipment not on EP, the delays must be defined and understood by all parties. Clarify if the designer intends for the delay to be between commands to start from the BAS or actual energizing of equipment or the time for the equipment to come to some speed. Once given a start command, an air handler with a slow ramp setting in its VFD will take some time to be drawing many amps. Likewise a chiller will have to go through its safety checks and will not normally start drawing amps for a minute or more after being given a command. It would be good to question the designer as to the purpose of the delays. If it is for reducing demand spikes for utility bill management, the window of kW demand evaluation should be understood and staggers planned accordingly.

Table 1 provides an example of an actual matrix developed for a medical office building, as well as columns for documenting execution of the test.

Test Plan

A test plan should be developed as early as possible during construction. Without a specific plan the test will likely fail the first few tries and significant time will be wasted. The plan provides an overview and objectives, a list of the test prerequisites and the role each player will have. The plan should also give a general chronological list of what will happen on test day and a specific test schedule (by hour and minute) for the events.

Overview Statement

An overview statement will help all players to "get the picture" of what the objective is for the test and how it is run. Language for a test overview statement is found below.

> The objective of this test is to verify that all equipment responds according to the response matrix when power is dropped from the entire building and when power is restored via the generator and later when normal street power is restored. Component testing alone is inadequate, as the interactions and real-life test often result in surprises. Auto-resets and the actual procedures for manual resets are tested. The results are verified for most equipment by visual verification in the field. For some equipment like numerous small terminal unit controllers, queries in the control system are acceptable. Documentation is done on test forms and for lighting and electrical outlets on the electrical drawings. The power is dropped from the building, the generator starts, and verification continues until complete. Then the normal power is restored and another round of verification is conducted.

Prerequisites

Prior to the test, the generator should have been successfully tested (with documentation) through its startup and load bank testing, along with any UPS integration and testing. To increase likelihood that equipment and systems are set up and programmed correctly, it is important to confirm that all components of each system have been tested through a power outage and responded properly. For complex sequences, like staggered equipment start up, it is recommended that the commissioning authority review the programming code of the sequences prior to the test being scheduled. Setting up any alarms and trend logs to document the test must also be done ahead of time. Table 2 is an example of the prerequisites of a specific project.

Table 1: Sample Emergency Power Response Matrix & Test Form

Ver: 4/3/2008

Superior Health Center, ABC Town

Response Key (see defin. below) **A**- Auto local restart (simple disconnect) **B**- Auto BAS or other controller restart **C**- Continuous Operation (on UPS) **D**- Manual BAS restart **E**- Emergency generator power **F**- Remains OFF **M**- Manual local restart **N**- Normal street power only **R**- Ride thru from E-power to Normal Power		Type of Power (Normal, Emergency or UPS)	Electrical Transfer: After Normal Power Loss	Electrical Transfer: At Normal Power Restore (& manual resets where indicated)	Sequence Notes	Infor Source	Special Test Procedures	Witnessing Party	Passed Both Tests of Col's X; Y?
1	**MECHANICAL**								
1.1	**Building automation system**								
a.	Local field panels (LP's) that are not on E-power (and are not listed below)	N	F	A					
b.	LP for AHU-01	E	B	B		ABC EL3A-9			
c.	LP for AHU-02	E	B	B		ABC EL3A-13			
d.	LP for AHU-03	E	B	B		ABC EL3A-9			
f.	LP for chilled water system	E	B	B		ABC ELR-25			
g.	LP for heating water system	E	B	B		ABC ELR-25			
h.	LP's for FCU's	NA	NA	NA	FCU's controlled with local T-stats. BAS monitors.	ABC 4/21/09			
i.	LP's for FSD's:	NA	NA	NA	FSD's on E-pwr. BAS has no interface.	ABC 4/21/09			
j.	LP's for VAV units	N	F	A		ABC			
k.	Refrigerators & freezers	N	F	A	Locally controlled. No BAS monitoring.	ABC 4/21/09			
l.	Network controllers (UNC-1; 2)	E, C	C	C	UNC control panels have a battery.	ABC 4/21/09			
m.	Workstation computers	E	B	A		ABC 4/21/09, EL1A-19 RFI ??			
n.	Gateway to county network	E	NA	NA	Non-issue. County networks into BAS.	ABC 4/21/09			
o.	Lighting control panel main bldg	NA	NA	NA	Lighting panel is Div 16. BAS interface not clear. RFI pending.	ABC 4/21/09			
p.	Monitoring of ATS	E	B	B	BAS ATS ctlr doesn't have a UPS & does not need one.	ABC 4/21/09, EL1A-19 RFI 185			
1.2	**Air Handlers**								
a.	AHU-01	E	B	R	On EP, max fan spd 25%.	E0.50 EHDBR, 15920 1.04-G.			
b.	AHU-02	E	B	R	" "	E0.50; E0.60			
c.	AHU-03	E	B	R	" "	E0.50; E0.60			
1.3	**General Exhaust**								
a.	EF-01	E	B	R	EF-01 does have VFD.	E0.50 EHDBR			
1.4	**Air Terminal Units**								
a.	VAV-1-xx	N	F	B	Dprs remain as-is at loss of power.	ABC 4/21/09			
1.5	**Chilled Water System**					15920 1.04-G			
a.	CH-01	N	F	B	"A rapid powerfail recovery capabilitiy shall return the chiller plant to its last state (before the building controller lost power) as quickly as possible after the building controller powers up." 15920 3.10-J.	E0.50; 15920-3.01-J			
b.	CT-01; -02; -03	N	F	B		E0.50 HDBR			
c.	CWP-1; -2 and CHWP-1; -2	N	F	B		E0.50 HDBR			
e.	Chiller room refrig detection	N	F	A		E0.40 NLR			
f.	CEF-1 chiller room fan	N	F	B		E0.50 HDBR			

Matrix Continued

Response Key (see defn. below)
- **A**- Auto local restart (simple disconnect)
- **B**- Auto BAS or other controller restart
- **C**- Continuous Operation (on UPS)
- **D**- Manual BAS restart
- **E**- Emergency generator power
- **F**- Remains OFF
- **M**- Manual local restart
- **N**- Normal street power only
- **R**- Ride thru from E-power to Normal Power

		pe of wer rmal, ner- cy or PS)	Electrical Transfer: After Normal Power Loss	Electrical Transfer: At Normal Power Restore (& manual resets where indicated)	Sequence Notes	Infor Source	Special Test Procedures	Witnes-sing Party	Passed Both Tests of Col's X; Y?
1.6	**Heating Water System**								
a.	B-1, 2; 3	E	B	R		15920 1.04			
b.	HWP-1; -2	E	B	R		E0.50 EHDBR			
1.7	**Fan Coil Units**								
a.	FCU-1-2, 1-4, 1-7, -1-5, -1-6	E	B	R		E0.50; E0.60			
d.	FCU-4-1, 4-2	N	F	B		E0.50 HDBR			
f.	CU-1, -2, -3; -4	E	B	R		E0.40 NLR.			
1.8	**Dental**								
a.	DV-1 vacuum pump &	N	F	B		E0.40 NL2B			
1.9	**Plumbing**								
a.	WH-1; WH-2 (water heaters)	N	F	A		E0.40 NLR			
b.	HRP-1 (recirc pump)	E	F	A		E0.50; E0.60			
1.10	**REFRIGERATION & BIO**								
a.	Refrigerator controllers	E	A	R		E0.50			
b.	Refrigerators Rm 1049, 1038	E	A	R		E0.50			
f.	Freezers, Rm 3061	E	A	R		E0.50			
2	**ELECTRICAL**								
a.	Generator (normal power to generator)	Generator to receive signal to start after 120 s of signal from BAS and within 10 s of that signal, generator provides acceptable power and ATS transfers to generator power.							
b.	Generator (generator to normal power)	During an outage, when NORMAL power is restored, the ATS will switch back to NORMAL power automatically after 20 minutes. The generator will continue to idle for 30 minutes before shutting down.							
c.	ATS	NA				E0.50	Check ATS mapping to BAS		
d.	Emergency electrical receptacles	E	A	R		E0.50			
e.	Emergency egress lighting	E	A	R		E0.50			
f.	Lighting controls	N	F	A		DEF 5/7/09			
3	**FIRE PROTECTION**								
a.	Fire alarm panel	E; C	C	C		E0.50			
b.	Fire/Smoke Dampers	E	C	C		E0.50			
c.	Fire Doors	E	A	R		E0.50			
d.	Elevator smoke screens Flr 1 EL1; 2	E	A	R	Will close if EP is not seen in 15s?	E0.50			
g.	Coiling doors	N	F	A	Will stop in place & require button to be pressed again to start?	E0.50			
h.	Call out to County staff (tele)	E; C?	C	C		E0.50			
4	**SPECIAL SYSTEMS**								
a.	Elevator, PE-1 (patient)	E	A	R		E0.50 EHDBA			
c.	Elevator, SE-1 (service)	N	F	A	Fails in place or returns to level ???	E0.50 HMSBA			
d.	Elevator sump pump & alarms	E	A	R		E0.50			
e.	Security system, incl. door	E; C?	C	C		E0.50			
g.	CCTV	E; C?	C	C					
h.	Data	C ?			By owner				
i.	Telecom	C ?			By owner				
j.	Nurse call equipment	E	A	R		E0.50; EL1			
k.	Paging equipment	E	A	R		E0.50; EL1			

Table 2: Prerequisites

	Task	Responsible Party	Done Date	Notes
1. Pre-Testing				
1.1	Generator and UPS have been successfully tested and accepted.	ABC & DEF		
1.2	All components of the system have been previously tested as independent systems and all functioned as required.	ABC & DEF		
1.3	Power is dropped to entire building as a pre-test to shake out any issues. This is managed by the contractdors and details are not formally documented.	ABC & DEF		
2. Control Code Review				
2.1	Review any sequential start program code to ensure it meets the intent of the contract documents.	SBE with DEF		
3. Pre-Test Day Tasks				
3.1	Verify required personnel safety gear for panel access are available.	Dennis T		
3.2	Verify that any necessary permits required have been obtained.	Dennis T		
3.3	Obtain needed receptacle plug testers.	Dennis T		
3.4	Obtain needed radios	Eric		
3.5	Notify parties interested in witnessing-only the test. County fire marshal, ops staff, design EE	Eric		
3.6	Notify occupants that power will be lost and they should shut down all computers and equipment they are concerned about.	Eric		
3.7	Contact the County IT and local fire dept of test and to ignore any alarms during the test.	Eric		
3.8	Test readiness meeting held the day before the test.	Summit		
3.9	Set up into trends all equipment desired, at 1 minute intervals and extended logs.	DEF		
3.10	Set up alarms for staggered start equipment (list):	DEF		
3.11	Control room BAS computers on UPS and E-power extension cord	Eric		
4. Just Prior Starting Test				
4.1	All participants have the hourly schedule and the Response Matrix to record results.	Eric		
4.2	Verify status of equipment.			**Tag ID** (circle when verified)
a.	Control Room. Check status on all equipment from BAS Navigation screen. Run Alarm Report on all equip.	John Doe		
b.	Roof. Field verify that all VFD's are in normal / auto mode.	JWM; HACO		AHU-01 SF; RF, AHU-02 SF, RF, EF-01, AHU-03, AHU-04.
c.	1st Floor			P-03; -04.
d.	Roof & 1st. Verify all ATS, UPS and Genset are in normal position.	ABC		
4.3	All parties synchronize their watches	All		At meeting.

Test Scheduling

Schedule the test when it will least interfere with other construction or occupant activities and not require contractor overtime. This is difficult with an occupied building and may have to be done after hours. If the test will include verifying emergency lighting, schedule the test for after dark. Since there is a good likelihood that the test won't pass completely the first time and may require some work by contractors prior to the retest, schedule the test in the morning, if possible. And since sometimes such tests resulting major glitches, equipment malfunction and shutdown, it isn't advisable to schedule them for a Friday, before the weekend.

General Test Procedures

As part of the test plan a list of procedures in chronological order should be given. Below is a list of procedures used for a specific project.

Table 3: Sample of General Test Procedures

1	Test shall be conducted when dark or near dark. (Not necessary. Fire Marshal has tested the lights already)
2	Execute all Test Set Up in the Overview, Prereqs and Planning table prior to conducting the test.
3	Provide all documenting or witnessing participants copies of this test and receptacle testers, plan drawings and radios to those doing floor checks.
4	*Open the feed to the building to break normal power. Identify the feed.*
5	For each piece of equipment, physically verify the response of the equipment in the field, unless noted otherwise: --Observe UPS operation, generator start and equipment restart. Time the special delayed starts. Verify that all devices on S-power in the Matrix are operating, except as noted below. (HVAC, mechanical, process, electrical, security, fire alarm & protection, telecom,etc). --Exceptions--NOT to be tested during this event: Fire alarm, fire protection and elec receptacles, but do check UPS receptacles unless this has already been done with the fire marshal. --Manually reset when required. In the Main Test form, check-mark the response cell (Col. X) if it matches the expected response. Mark in Passed? col. if both tests passed. Footnote and explain any variances. --Document the staggered start sequences in the Start Delay test form.
6	Assess success of test and make plans for any corrections and retesting.
7	*Once all documentation is complete, restore normal power.*
8	For each piece of equipment, physically verify the response of the equipment in the field, unless noted otherwise. Manually reset when required. In the Main Test from, check-mark the response cell (Col. Y) if it matches the expected response. Mark in Passed? col. if both tests passed. Footnote and explain any variances. Document the staggered start sequences in the Start Delay test form.
9	Assess success of test and make plans for any corrections and retesting.

In addition to the general test procedures, a specific hourly schedule may be appropriate, particularly when staggered start times are being verified. Table 4 provides a sample of such a schedule for a specific project.

Table 4: Sample Whole Building Power Outage Hourly Test Schedule

Time	Test	Process Summary	Lead
10:30a - 11:00a	Misc. prerequisites	Alarm report, VFD's & elec equip in normal. See Overview & Prereqs for details. Synchronize watches.	DEF & CU
11:00 - 11:30a	Meeting in control room	Review test and coordinate responsibilities	Walt A
11:30a - 12:30p	Normal to Standby test--HVAC, mech, process & security	**Drop normal power.** Observe UPS operation, generator start and equipment restart. Time special delayed starts. Verify that all devices on S-power in the Matrix are operating, except as	Walt A; Dennis (CU)
12:30p - 12:45p	Meet in control room	Discuss issues and timing to make necessary corrections. Prepare to restore to normal power.	Walt A
12:45p -2:00p	Standby to Normal test	**Restore normal power.** Check equipment same as Normal to Standby.	Dennis
2:00p - 2:30p	Main test debrief in control room	Discuss issues and timing to make necessary corrections and retest.	Walt A & Eric
2:30p - 3:30p	Make necessary correctioı	Disable generator and drop all power to building if necessary. Conduct electrical work and prepare for retesting.	All
3:30p - 4:00p	Normal to Standby test for failed equipment.	**Drop normal power.** Test previously failed equipment.	Dennis
4:00p - 4:15p	Test debrief in control room	Review test results and prepare for Standby to Normal	Walt A
4:15p - 4:45p	Standby to Normal test	**Restore normal power.** Check previously failed equipment.	Dennis
4:45p - 5:15p	Test debrief in control room	Discuss issues and timing to make necessary corrections and retest.	Walt A & Eric

Pretesting

Pretesting will require a joint effort between subcontractors. Each subcontractor should be made responsible to pretest the response of their equipment in two different modes before the formal documented test. First, they should test the response to their equipment by tripping breakers or feeders. Second, the contractor should coordinate a pre-test of the whole building shutdown by actually shutting down the power to the building while the contractors observe their equipment responses relative to what is specified in the response matrix. The whole building shutdown pretest need not be formally documented, but the commissioning authority should confirm that it was completed and issues corrected before scheduling the formal documented whole building shutdown test.

Participant Roles

The number of staff involved in tests will vary by project. There are three primary roles: executing the test (dropping street power, running the BAS, etc.), documenting the results, and being available to deal with any glitches with the individual’s equipment. A test may only require the electrician, controls technician and commissioning authority to execute and document, but it is very advisable to have a party on site representing every piece of equipment being tested or that will affect the tests. Without these staff on site, a small problem, easily fixed if the right person is on site, turns into a failed test and a required repeat for half-dozen or more contractors. This means the controls, electrical, mechanical, general and fire alarm contractors should always be on site for the test. Having the security, data and other specialty contractors on site or at least committed to be on call during the test is advised. Other witnesses may also desire to be involved from the owner's operations staff and from the design team.

The test plan should indicate the roles of each individual. Table 5 gives an example of general roles and Table 6 gives specific staffing locations, normally only needed if staggered starting is being verified by visual observation.

Table 5: General Staffing Roles

Party			Task During Test
Summit commissioning coordinator	Walt A		Overall coordination and test director.
General contractor	Alan A		Coordination with Summit and subs.
CTC mechanical	Adam C		Lead mechanical. Will be there to assist in any issues with performance.
CTC mechanical	Craig J		Lead mechanical. Will be there to assist in any issues with performance.
AAX controls lead	Steve T		Lead controls. Operate BAS.
AAX field tech			To assist in testing.
AAX staff at Owner Remote monitoring room			Witness remote response
DEF electrical	Dennis		Operate the generator, ATS & other elec equipment.
Liebert UPS rep			Deal with UPS issues
TZA security			Security
TZA fire alarm			Fire alarm
TZA data & telecom			Data and telecom
LLT lab controls			lab hoods and controls
Owner Ops			
Owner IT			

Table 6: Sample Staffing Locations

ID	Initial Location	Equipment to Check	Matrix Line Item to Verify	Radio?	Party
1	Ctrl Rm	Network controller (CX's) and all equip status & perform BAS resets	1.1-a - o; q, 1.4-a; b.	Y	DEF
2	Ctrl Rm	Various	assist EMCOR	Y	Summit
3	First floor	Chillers, pumps, compressor	1.1-p, 1.6-a, b, e, f, g, h, 1.9-b, c, d, e, f, g, i,	Y	ABC
4	First floor	AHU-05; ACCU's	1.2-e, 1.8.		DEF
5	Roof	AHU-01 thru 04, EF's	1.2-a, b, c, d, 1.3, 1.8	Y	DEF
6	Roof	Boilers, CT's, LAC	1.6-c; d, 1.7, 1.9-k, l.	Y	ABC
7	Various	Security	3-p, q	Y	CTC
8	Various	Data & telecom	3-r, s.	Y	CTC
9	Various	Evidence freezers	1.9-h	Y	DEF
10	Various	Hoods	1.5	Y	Smiths

Managing the Test

Execution

Once all the prerequisites and setup tasks listed in Table 2 are completed, the test can be executed. A test readiness and coordination meeting the day before the test is advised. In that meeting go over the prerequisites in Table 2, the process as listed in Table 3, the staffing roles in Tables 2 section 5 and Tables 4 and 5, and the hourly schedule in Table 4.

The day of the test, just before the test start, have another meeting to kick-off the test and go over any last minute issues and bring members who missed the meeting the day before up to speed. Make sure everyone has a copy of the test hourly schedule (Table 4) and the Response Matrix (Table 1) where they can record results. Synchronize watches if visual observations will be used for verifying staggered starts.

Just prior to dropping street power, verify in the field that all VFD's are in normal or auto mode. From the BAS, go through each screen and see that all systems are in auto/normal mode. Run an alarm report on all equipment to ensure none are in alarm. Verify that each ATS and generator is in normal mode.

If the BAS workstation is not yet on a UPS and there is staggered starting equipment, it may be good to temporarily put the workstation on a battery so that it can stay live during the transition from street to emergency power and record timing issues.

When street power is dropped, an announcement is made over the radio and parties make their assigned observations. When staggered starts are not involved, the test is fairly simple with only a few staff making the observations by walking around to each piece of equipment and through the BAS. They record what state the equipment is in and whether it matches what was specified in the Response Matrix. After the documentation is complete, parties meet and assess the success of this part of the test, noting any items that need correction or adjustment.

Then, normal street power is restored and participants again record the status of the equipment, comparing it to what is specified in the matrix. The actions, if any, required to restart equipment at this point is a critical element of the test. After the documentation is complete, parties meet again and assess the success of this part of the test, noting any items that need correction or adjustment.

Plans for making corrections and for retesting are then made.

Documentation

Instruct participants to write down all relevant observations, particularly if they are not expected. Even if timing is not critical, recording the exact time of observations each party makes can assist in trouble shooting problems that may arise.

Documentation will normally consist of the Response Matrix filled in with checks and initials of the party witnessing the event. These are compiled and merged onto one final test form by the commissioning authority. Using trend and alarm logs to document these tests may also be appropriate. For additional guidance on trends and alarm logs see Special Issues for Staggered Starts section below.

When staggered starts are involved, alarm logs and possibly trend logs may also be required along with the special visual records with the exact time of events recorded.

Special Issues for Staggered Starts

When staggered starting of equipment is required, the test documentation is significantly more complicated. Three methods have been used: visual field witnessing, viewing status at the BAS workstation, trend logs or alarm records. Some projects will require a combination of these methods because all equipment is not under BAS monitoring, and sometimes it may be desired to get a "warm fuzzy" from actually seeing the equipment start, rather than solely depending on the BAS readouts.

Visual Field Witnessing. If the visual verification method is used, create a table of each piece of equipment in the staggered schedule, and in adjacent columns have a place for each witness to record the exact time the equipment starts and a place for initialing as the witness. This requires multiple people to be in the field to witness the different pieces of equipment start up. All witnesses should calibrate their watches together at the beginning of the test. Be sure to define what constitutes a "start" for equipment with safety prechecks like chillers (start of safety checks or actual compressor start).

Viewing Feedback at the BAS Workstation. Using the BAS workstation may be acceptable for verification if the staggers are greater than a minute or so. This depends on the specific control system being used, since the BAS network and refresh speed may otherwise be too slow to make this method reliable, and moving back and forth between screens may be complicated. Note whether you are verifying the BAS commanded values or the actual status of equipment based on feedback and whether the feedback is the time the unit starts its internal checks or if it is the start time of the actual motor or compressor. This should have been defined in the notes to the power response matrix.

Temporarily adding all the inputs for the staggered equipment onto one existing BAS screen could also be used to facilitate recording the staggered starts.

Trend Logs and Alarms. Setting up trends of the equipment feedback can also be a method for documenting staggered starts. Using change of value (COV) is workable for some BAS's, but be sure it uses the "to the second" value and doesn't have a minimum resolution of 1 minute like some systems, which will mean you don't know when within the minute that the COV actually came in.

Likewise, trending the point status may not be able to be accomplished at tight enough intervals, depending on the speed limitations of the system and capacity and data downloading capabilities of the controllers. Requiring trending at five second intervals for a number of pieces of equipment simultaneously would not be uncommon. This should be pretested to make sure the BAS trending can be accomplished at this rate without dropped samples.

One method that works for all systems, including those with unacceptable COV and trending capabilities is to set up temporary alarms for the status points of staggered equipment. This method will give a straightforward time stamp whenever the status changes. This can be easily printed out in a query or obtained from the alarm record to document the staggered starts.

Conclusion

The whole building shutdown test verifies the interactions of a number of different pieces of equipment ensuring that life safety, product and equipment protection, comfort and O&M staff convenience are not compromised during a power outage. The performance criteria for the test must be completely documented, usually in a response matrix table. The test involves multiple trades and requires careful coordination. The test can be successful if a detailed plan is developed that includes an overview and objectives, a list of the test prerequisites, and the role each player will have. Equipment components should be tested prior to the formal power outage test. Staggering restarts of equipment by specified time delays can be verified by careful planning and sufficient witnesses or special temporary alarms set up in the BAS to record the startup of equipment.