ARES PROCEDURES FOR GENERATOR HOOKUP IN EMERGENCIES

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Experts tell us that the only really safe way to connect an emergency generator to a building's wiring is through the use of a transfer switch. This switch, which must be installed by a licensed electrician in advance of the need, guarantees that the generator cannot accidentally send power over the local electric utility power lines, and hence risk injuring or killing repair personnel.

In a perfect world, every building that might ever need emergency power would have a transfer switch. In the real world, this is clearly not the case. Consider the plight of an ARES jump team dispatched to assist a local sheriff in a rural county, who has been without power, radio communications or phone service for days. The team may have a portable generator, but no easy way to hook it up to the building wiring.

The only conventional alternative for the team would be to possibly spend hours stringing hundreds of feet of expensive extension cords and temporary lighting through the building, and expend a fair amount time and energy on trial and error techniques to optimize the restoration of service without blowing a circuit breaker, and interrupting service again.

Here's a real-world example of the pitfalls associated with using extension cords. Suppose you have an 1800 W generator, and need to deliver power about 100 feet away. You scrounge up four used 25-ft. fairly sturdy extension cords and you think you are in business. You carefully hook up enough equipment to just equal 1800 watt load, and then suddenly your expensive HF rig goes up in smoke! Where did you go wrong?

The devil was in the details. A typical 14-guage 25-foot extension cord has 0.2 ohms resistance when the length of wire and connectors are taken into account. Four cords gives you 0.8 ohms. 1800 W would draw exactly 15 amps of current. 15 amps flowing through .8 ohms would cause a voltage drop of 18.75 Volts, so if you started with 120 volts at the generator, you would only have 101.25 volts at the other end. That voltage would be 15 % lower than it should be and could easily cause a power supply to burn up. Most equipment is designed to work with only a ± 10 % variation in voltage.

On the other hand, using building wiring as much as possible will minimize this risk.

The procedure outlined here would allow a generator to be connected to the building wiring at the sheriff's office in a matter of minutes, and provide power to a some of the outlets and lights in the building (typically one room's worth). This could potentially get the sheriff back in business in the minimum amount of time. This procedure, if strictly followed, step by step, will ensure the safety of all personnel and equipment, but it is a long way from fool-proof. It is appropriate for technicians who are knowledgeable in the fundamentals of electricity, and who have enough common sense to strictly follow these instructions to the letter.

On the other hand, in the hands of someone in a big hurry, or someone not familiar with the use of a VOM meter, this procedure could spell big trouble. Let the reader beware.

NOTE: Most buildings having single-phase 240 V service are divided in half electrically. Roughly half the outlets and half the lights are served by the first leg of the 240 V service, and the other half are served by the second leg. All outlets in a single room may be served by the same leg. The procedure discussed here will apply power to only one leg of the service, meaning that at least half the building will be out-of-reach of this procedure. If you are lucky, the radio room will be in the served half on your first try. If not, you may have to feed a different outlet.

Power limits Discussion: The limiting factor in this approach is the amount of power that can be safely handled by one conventional consumer A.C. power plug and mating receptacle. This in turns limits the power that may be carried by our extension cord and jumper. The current limit for such a plug is 15 A, so we are limited to 1800 Watts (15 A x 120 V = 1800 W) , regardless of the capacity of the generator. This would be the equivalent of eighteen 100-watt light bulbs, or perhaps thirty-five to fifty flourescent bulbs. In our scenario, this might be enough to supply two 100-watt transceivers, four box fans, eight 50-watt flourescent light fixtures and 1 desktop PC. If the generator is capable of higher than 1800-Watt output, additional appliances could be connected directly to the generator via additional extension cords, while keeping in mind the incumbent and possibly hazardous voltage drop.

The point of this exercise is to get a significant number of lights an appliances in service quickly, but avoiding wasting time and resources to duplicate building wiring with temporary extension cords, gang adapters, power strips and lighting. This approach also avoids the safety hazzard of having multiple extension cords run through doorways, hallways and across the floor.

The scenario: As described above, a small office building or residence has been without power for several days. The building is equipped with conventional 240 V, single-phase AC wiring, provided through a single circuit breaker box, with all circuits labeled, and having a single master-disconnect switch. A group of ham operators has arrived on scene with a portable generator which offers 120 VAC, 60 Hz, single-phase at 1800 watts (1.8 KW) or greater.

Equipment: In addition to the portable generator mentioned above, the hams will need a sufficient supply of fuel (typically gasoline) and crankcase oil to cover the operation of the generator for the duration of the assignment. Ideally, the served agency could make arrangements for un-limited supply.

The ham team will also need the following equipment:

GENERATOR KIT

1) A heavy-duty, 3-conductor extension cord, 12 gauge, about 50 ft long. (Available from Lowe's for about $40.)
2) 5-gallon fuel container and funnel
3) Tarp large enough to cover the generator in operation
4) 120 V fluorescent drop light
5) 10-ft. heavy-duty chain with padlock
5) Flashlight with fresh batteries

ACCESS PORTAL ROOM KIT

1) A special A.C. jumper cable, 6 - 8 ft long, 3-conductor, 12-gauge, with 3-conductor AC power plugs installed on *both* ends. (This cable should be kept under lock-and-key when not in use. In the wrong hands, it is an invitation to trouble.)
2) A Volt-Ohm meter, capable of measuring at least AC Voltage and Resistance, with test leads.
3) A P3-brand "KILL A WATT" meter. Available from http://www.killawattplus.com for $22, or $26 from Radio Shack.
4) A roll of duct tape
5) Flashlight with fresh batteries
6) Generator log book (See sample page below)
7) Ball point pen
8) A bath towel

CIRCUIT BREAKER ROOM

1) Laminated sign type-1 reading as follows: (See page 12)
WARNING: *This disconnect switch MUST remain in the* ***off*** *position until further notice. Do not reset this switch under any circumstance.*
2) Sign type-2 reading: (See page 12)
WARNING: *All circuit breakers in this box except those specially tagged must remain in the* ***off*** *position until further notice. Do not reset any breaker under any circumstance.*
3) Laminated Sign type-3: (See page 11)
NOTICE TO UTILITY PERSONNEL: *Generator in this building is* ***not*** *connected to mains.*
4) A felt pen and supply of paper tags with small tie-wraps or strings to secure to breakers.
5) A pair of FRS radios or 2m H/T's.
6) A small padlock (size suitable for use on a school locker.)
7) A roll of 3/4" blue masking tape
8) Flashlight with fresh batteries.
9) Optional, but very helpful in buildings with missing or ambiguous breaker charts: Toner and speaker probe (with fresh batteries) of the type used by telephone repair personnel. With the toner connected to an outlet, the probe will readily identify the serving breaker if it is in the *OFF* position. See http://sandman.com/repair.html for several choices.

THE PROCEDURE:

Building Survey

1) Conduct a scene survey, and verify that there is a safe location to operate the generator which is protected from rain but is sufficiently open to outside air to guarantee that there will be no danger of carbon monoxide fumes accumulating during operation. A non-enclosed back porch would be a good example of a permanent structure. A tarpaulin carefully secured over a pair of sawhorses might serve as a temporary structure. This must be located within about 35 feet of a door or window to the building. The best location would be just outside a roll-up door leading to the circuit breaker room.

It is preferable to locate the generator in the back of the building for a number of reasons. First, if

a door must be propped open, a back door is slightly more secure. Second, if the generator can be seen from the street, it is more likely to be stolen or tampered with. The economics of a disaster situation can turn normal citizens into thieves in minutes. Consider the plight of a gas station owner who does not have a generator. If he stands to loose thousands of dollars every day he is without power, his values may change abruptly! Look for a tree or a fence post you can chain the generator to. In a pinch, you could chain it to a trailer, or a trailer hitch that is not going to be moved.

The 12-gauge extension cord will have to be routed through a window or the door into the building. A window is preferable due to security considerations. Once the cord has been pulled through a window, the window should be closed as much as possible without damaging the cord. It may be desirable to cover the remaining crack in the window with a towel or duct tape to keep out rain, bugs and noise.

If using a door is necessary, and the door is a roll-up door, or has sufficient clearance between the floor the and bottom of the door to accommodate the cord (without damaging it) the door can be closed and locked. If not, the door would have to remain propped open (or at least cracked) as long as the generator is in use to protect the extension cord from damage. The building occupants would have to accept the decrease in security this represents, and any insects or rain that come with it.

In the remainder of this discussion, this door or window will be referred to as the *access portal*.

If the access portal leads to the room with the breaker panel, life will be much simpler. If not, a team of two workers equipped with radios will be needed to conduct the tests outlined below.

2) Gain access to the master-disconnect switch for the building. Ensure that there are no obstructions (locked switches, locked panel covers, gear adrift, etc.) which could interfere with access. Newer buildings may have the main-disconnect switch located outside near the electric meter.

3) Gain access to the circuit breakers serving the room to be provided power. Ensure that there are no obstructions (locked switches, locked panel covers, gear adrift, etc.) which could interfere with access. With the assistance of a knowledgeable building occupant, identify the exact breakers serving the wall outlets in the room to be provided power, and the breakers serving overhead lights in the same room. Tag these breakers as follows: *LOAD 1, LOAD 2* etc.

Assuming that all or most breakers are found in the ON position, identify any breakers that are found in the OFF position, and cover them with 1 strip of blue masking tape. (If a breaker is kept off, there is usually a good reason, but known only to a few building occupants.) This will enable all the breakers to be restored to their original position when the power is restored to the building.

4) With the assistance of a knowledgeable building occupant, identify the exact breaker serving the wall outlets in room which has the access portal. (Use toner and tracer if available and necessary.) Mark this breaker with a tag reading *GENERATOR*.

If the breaker has been correctly identified, it can usually only provide power to other circuits having breakers an even number of standard-sized breakers away from it. (e.g. 2 breakers up, 4 breakers down, etc.) and breakers on the opposite side of the panel aligning with the served breakers. These will be the breakers powered by the same leg of the 240 V service. Check to see if any of the breakers marked *LOAD* will qualify. If not, you may have to find another outlet (presumably in another room) to connect to the generator.

5) Meet with the senior served-agency officer present, and building owner if available, and secure their signatures on the enclosed written agreement, and ensure they understand the terms and expectations included.

Power Restoration: (To be started only after written agreement is signed.)

6) Assign two knowledgeable personnel to set up the generator in the designated location, and set up temporary shelter if necessary. The generator should now be topped up with oil and gasoline. It may be started but not connected. Make note in the log of the time the generator starts running for future reference. Have them route the 12 AWG extension cord from the generator through the access portal, and secure the cord and portal as appropriate. (e.g. floor mats to prevent tripping, towel covering window crack, duct tape, etc.) Exercise caution with window screens. Do not damage screens unless absolutely necessary.

7) Throw the master-disconnect switch to the *OFF* position and affix Sign Type 1 over it. If possible, place a padlock on the switch to prevent unauthorized resetting. Let your team know where the key is stored.

8) Throw all circuit breakers in the breaker panel to the off position.

9) Unplug all 120 V appliances in the room with the access portal. Identify a power receptacle close to the access portal and check the outlet with the Volt-Ohm Meter for any voltage (AC or DC) If there is any voltage present, do not proceed until it is eliminated.

10) Check the same receptacle for continuity across the hot and neutral terminals. (e.g. the parallel slots). The reading should be above 1 M ohm. (or infinity) If not, do not proceed until continuity is eliminated. (Check light switches and appliances in this and nearby rooms if continuity is a problem)

11) Throw the breaker with the *GENERATOR* tag and a breaker with a *LOAD* tag to the *ON* position, and check the continuity again. You should see a resistance reading of less than 100 Kohms or so. (A single cold 100 watt bulb should show a resistance reading of about 100 ohms) If not, the load breaker may be on a different 240 V leg, or there may be no appliances or lights turned on and connected to that circuit. Try any other load breaker for continuity. If you find one that affects your continuity, you are in business. If not, additional investigation is indicated.

12) Reset all of the above breakers to the *OFF* position.

13) Have a helper go to the room(s) served by the breaker(s) and turn off all lights and unplug all power cords from the wall.

13) Start the generator and connect the plug of the 50 ft extension cord to one of the generator power outlets. Secure the female end of the extension cord to something close to eye level near the receptacle. Plug in the KILL A WATT device to the end of the extension cord. Check for a voltage between 108 V and 132 V. If the voltage is not inside this range, your generator needs adjustment or service - do not proceed.

14) Use the KILL A WATT device to check the frequency (Hz). If the frequency is not between 54 Hz and 66 Hz, your generator needs adjustment or service - do not proceed. (A simple carburetor adjustment might fix this.)

15) First plug the dual-plug jumper firmly into the wall outlet identified above. Then plug the other end into the KILL A WATT outlet. Check the current (Amp). If the current is not zero, it means that some appliance or device connected to this circuit is still turned on. This is not a big problem, but if you can identify it and secure it, you can save some power and gasoline.

16) Find a *LOAD* breaker identified above that is on the same leg as the *GENERATOR* leg, and turn it on. Check the current reading on the KILL A WATT device. Have a helper go to the room served by the breaker(s) and turn on devices one at a time in the order of importance. (Most critical first.) Monitor the current on the KILL A WATT device while this is happening. Stay in touch via H/T's on simplex or FRS radios during this process. If the current drawn shown on the KILL A WATT exceeds about 13 Amps, have the helper stop turning on devices.

17) If the current drawn stays below about 10 A, you can experiment with activating other breakers after first securing all lights and appliances on that circuit, and again ramping up current consumption by gradually turning on additional devices or lights. For example, if there is adequate light in the radio room, you might want to try turning on some hall lights.

You should avoid turning on any of the following:

1) Any 240 V device (these have two breakers that are connected by a bar, or one breaker that is twice as tall as most of the others)
2) Any devices with heavy-duty electric motors or compressors, including
    a) Air Conditioners.
    b) Freezers and refrigerators
    c) pumps
    d) air compressors
3) Microwave Ovens
4) Electric heaters
5) Hair dryers
6) Projectors
7) HF Linear amplifiers
8) Washing machines
9) Dish washers

18) Monitor time running (Hour) and the Kilowatt hours consumed (KWh) on the KILL A WATT. Make note of readings in writing in the generator log at least every half hour. These

will be used after the gas runs out the first time to establish a refueling schedule for the generator. The generator should need gas at about the same KWh reading each fueling cycle, so a shutdown for refilling may be roughly predicted. The time running will also give you a clue as to when the generator is running low on gas, but it will not be as accurate as KWh. Note that the KILL A WATT meter will be reset to zero each time the generator stops, hence the need to record regular readings during the first tank of gas, *before* it runs out

SCHEDULED MAINTENANCE PROCEDURE

19) You should plan to refuel the generator at least every time the kilowatt-hour reading gets within 10 % of the reading where it last ran out of gas. (Generators that run completely out of gas are harder to start.) As you get a feel for the timing, you can establish fixed schedule (e.g. every 4 hours.) You will want to stop the generator, check the oil and refill the gas tank each shutdown. Your served agency will appreciate advance notice and reminders of pending shutdowns. Use an alarm watch to keep your team on schedule. NEVER attempt to refill the generator gas tank while it is running.

20) To shut down the generator, first grab a flashlight and turn it on. Then turn *OFF* the breaker(s) labeled *LOAD* and *GENERATOR.* Also turn off any other appliance(s) connected directly to the generator. This will enable the generator to start easily after maintenance.

22) Stop the generator and check and service fluid levels. Check your maintenance log to see if scheduled maintenance is required, or will be before the next scheduled shutdown. Please note that some generators specify an oil change every 20 hours of operation. If your generator is running continuously, this means you will need to do an oil change **every day!** See Appendix 1.

23) After maintenance is complete and the generator has restarted, let it run for about 1 minute before applying load again. Check the voltage and frequency readings on the KILL A WATT device and record in the log.

24) Turn on the breaker tagged *GENERATOR*.

25) Turn on the breakers tagged *LOAD.*

COMMERCIAL POWER RESTORATION PROCEDURE

NOTE: This procedure is absolutely essential. Serious injury to personnel and property could result if not followed.

You may become aware that power has been restored in the neighborhood by word-of-mouth, or as a result of seeing lights in other buildings. It is not uncommon for the power restoration to have several false starts before it becomes stable. You may wish to coordinate restoration of commercial power with the next scheduled generator maintenance. You should collaborate with the senior served agency official about timing for restoring commercial power to the building. Be sure to ask for the assistance of a member of his staff, so you can hand-off responsibility for the building power and control of the circuit breaker panels.

When that time comes, use the following procedure:

1) Send a runner to warn building occupants of the impending power loss. Ask them to secure all light switches in the building.

2) Turn all circuit breakers to the *OFF* position.

3) Unplug the double-plug jumper from the KILL A WATT device first

4) Unplug the other end from the wall outlet second and then immediately plug in the KILL A WATT device into the same wall outlet.

5) Remove the padlock and sign type 1 from the main disconnect switch, and reset it to the *ON* position.

6) Reset the breaker marked GENERATOR to the ON position, and use the KILL A WATT to check the voltage and frequency of the commercial power. Check for a voltage between 108 V and 132 V. If the voltage is not inside this range, commercial power is not stable - do not proceed. Check the frequency (Hz). If the frequency is not between 54 Hz and 66 Hz, commercial power is not stable - do not proceed.

If the power is not stable, return to generator power by: repeating step 7), 24) and 25) above.

If the power is stable, proceed with the following:

7) Instruct the member of the building staff to start resetting each circuit breaker to the *ON* position (except those previously marked with blue tape.) Turn on double breakers (240 V) first, waiting about 20 seconds between each breaker, and then single breakers, waiting about 10 seconds between each breaker.

8) Ask him to send a runner to advise building occupants that commercial power has been restored and that it is safe to start turning on lights and appliances. He should also ensure that all appliances that were powered before the outage are plugged in again.

9) Radio or send a runner to secure the generator. Allow it to cool before moving.

10) Remove all remaining temporary signs, locks, tags and tape from the breakers.

11) Remove sign type 3 from the front of the building.

12) Secure remaining equipment when it is clear that the commercial power is stable.

13) Close the window of the access portal and replace screen if appropriate. Close and lock the access portal door, if appropriate.

14) Make appropriate notes in your log. Ensure follow-up action if your generator is now due for service.

WHAT IF YOU NEED MORE POWER, OR MORE ROOMS?

There are ways to provide more power or service more rooms with building wiring. They will be mentioned in passing here, but detailed instructions are beyond the scope of this article.

1) You could power both legs of a 240 V service by running a second 12 AWG extension cord and double male jumper from the generator to a second wall outlet, on the second leg, likely in a second room. Note that your generator does not need to furnish 240 V for this approach, and you still cannot power any 240 volt appliances. Your total wattage would be limited by the capacity of your generator, and neither cord could carry more than 15 A.

2) You could provide 2400 watts to one leg if you connect a 20-amp outlet on your generator to a 20-amp outlet in the building using special 20-amp cords and connectors. A 20-amp outlet looks just like a conventional 15-amp duplex outlet, except the neutral conductor looks like a "T" lying on its side. (Remember: *Lazy "T" means Twenty.*) 15-amp plugs have parallel blades, while 20-amp plugs have perpendicular blades. All your cords must be 10 AWG or larger. A 50 ft, 3-conductor, 10 AWG extension cord, with special plug and outlet, is available from Lowe's for $55. Your generator breaker must be 20 A or larger.

3) You could provide 30 A or 3600 W through a 30 A extension cord with adapters. These 30 A cords are available from RV dealers, but you will have to fabricate adapters for both ends of the extension cord. The building end adapter should have two conventional 15 A plugs to connect to two wall outlets on a single, 30-amp circuit, or two 15-amp circuits.

4) If your generator can supply 240 V through a 4-wire, 240 V, twist-lock receptacle, you could fabricate an extension cord/ jumper to mate with a 240 V dryer outlet in the building. This will power both legs of the panel, and could reach every room in the building. Note you are still limited by the power output of your generator, and the ampacity of the dryer circuit breaker. (Typically 60 A per leg.) Four-conductor, 8-AWG, Type-SO wire is recommended for the custom extension cord. NOTE: The custom cord *must* be connected to the dryer outlet *first*.

GENERATOR MAINTENANCE LOG

Generator Brand_____ Model _____ Power Output _____Watts Date of last Maint.___/____/____

Recommended Maintenance Interval _____Hrs. Run time since last maintenance brought forward_____Hrs

Instructions: 1) Make an entry at least each time generator is stopped, and more often as needed.
2) Record time in hours and hundredths to make math easier.
3) Circle any reading that is abnormal or requires attention

Date	Time	Run Time (HH.hh)	Cumulative time since last maintenance	Output (Volts)	Frequency (Hz)	KWh	Gasoline used (Gal)	Oil used (oz.)

Recorded by ______________________________________ Reviewed By_______________________________________

NOTICE TO UTILITY PERSONNEL:

Generator in this building is ***not*** *connected to mains.*

WARNING:

This disconnect switch MUST remain in the ***off*** position until further notice.

Do not reset this switch under any circumstance.

--Cut apart here--

WARNING:

All circuit breakers in this box except those specially tagged must remain in the ***off*** position until further notice.

Do not reset any breaker under any circumstance.

The Amateur Radio Emergency Service (A.R.E.S.) is in the business of providing radio communications services during disasters and other emergencies. Because our equipment requires electrical power, this team is equipped with one or more emergency generators capable of providing 120 VAC to our equipment, and in special cases, to the agencies and buildings we serve. A.R.E..S. is not an electric utility, and cannot assume any liability for damage to equipment due to power failures, voltage reduction, loss of service, loss of business, or any other failure of our equipment or personnel. We are, however, knowledgeable technicians familiar with basic electrical and electronic theory who have all been licensed by the F.C.C. as amateure radio operators. When we provide electrical power, it is always done using well-tested procedures designed to optimize dependability, and ensure optimum safety to all personnel and equipment. This document is part of our standardized procedures.

We propose to provide electrical power to a limited subset of your building's lighting and appliance circuits, starting approximately 30 to 60 minutes after this agreement is accepted, and continuing for 1) the duration of our assignment here, 2) until dependable commercial power is restored, or 3) until this agreement is canceled by either party. This proposed service will be subject to acceptance of and full compliance with the following terms:

1) ARES will not charge for this service, but we to ask that our fuel and oil expenses be reimbursed, either by check or in kind. The best arrangement would be for your staff to make arrangements for fuel and oil, as specified in Attachment 1, to be delivered to our generator site as needed.

2) Our equipment will need to be shut down on a scheduled basis for refueling and maintenance. This will result in loss of power approximately every 4 hours for about 15 minutes, and once a day for about 30 minutes. The exact time between shutdowns will depend on power demands from your building and the particular maintenance requiremets of our generator. We will keep your staff posted as these figures are worked out. We will be happy to work with your staff to schedule these shutdowns at the most convenient possible times, but they cannot be skipped.

3) Complete control of the main disconnect breaker and panel box breakers serving your building will be turned over to ARES staff for the duration of our services. No one from your staff will be allowed to activate any additional breakers under any circumstances, and they may secure breakers only in an emergency. Failure to follow these conditions could result in serious injury or death to utility personnel.

4) The amount of power we can furnish to your building will be limited by the capacity of our generating equipment, and our temporary wiring. The total number of watts available is shown in Attachment 1. By way of reference, every 100 watts can operate a single 100 watt lightbulb, so an 1800 Watt service could operate 18 such bulbs.

5) If additional generators should become avilable, they will not be placed in service in the served building unless they are connected and operated by our staff.
6) Arrangments for temporary wiring to be brought into your building will result in a compromise in security - typically a requiring a door or window to be left ajar. In rare cases, a window screen

may be damaged. The served agency accepts full responsibility for the consequences of these actions, and agrees to hold ARES harmless. Once the wirng has been routed, the served agency will take all measures necessary to maintain minimum security standards under the compromised situation.

ACCEPTANCE OF TERMS

For A.R.E.S.

_____ _____ ___/___/___

Name

Title

Date

For served agency:

_____ _____ ___/___/___

Name

Title

Date

ATTACHEMENT 1

FUEL SPECIFICATIONS_____

OIL SPECIFICATIONS_____

TOTAL POWER AVAILABLE FROM GENERATOR _____ Watts.