The Principles of Power Distribution

Presented by

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What questions need to be asked to ensure a successful power distribution project?

Know your Audience!

- Who are you working with to develop your plan?
- Are you talking to the correct person?
- Do they know the actual requirements and understand electrical generation, and distribution?
- Ideally, you want to be working with an electrical contractor, electrician, engineer, or equivalent.
- Facility managers, building operators or maintenance staff may also have the required information.
Local Regulations and Project Type

• Are there any specific local regulations that you will need to contend with for the project? Special permits, inspections, etc.
• What type of project is it? Commercial/Industrial, Special Event, Concert/Festival, etc.
• Exposure to the general public will typically involve additional safety measures. Cable protection mats, connection enclosures, fencing, labelling/signage, etc.

Total and Individual Loads

In order to calculate the correct generator size you need to determine the total load requirement. Be mindful if using T-4 engines as minimum loads (+30%) need to be maintained.

Assuming typical North American low voltages (600V and below) and 60Hz.

• How many individual loads are there?
• What is the voltage and amperage requirement of each load?
  o Multi voltage requirements will most likely require the use of XFOs.
• Are there any special connectors required? Hubble twistlock, C-Form, Joy, NEMA, etc.
Site Layout and Cable Routing

- Do you have a site plan? Many larger outdoor events will have a CAD drawing for specific locations and cable runs.
- If a site plan is not available, a site visit may be required depending on how complex the distribution system is.
- What is the location for each load?
- You need to determine how long each cable run needs to be from the generator.
- Voltage drop could be a concern for longer cable runs. Especially at lower voltages, with smaller gauge cables.
- Generator grounding location and type. Plate or rod, bldg, hydrant, etc.
- Generator placement/parking location. Truck and service access. Minimize cables crossing roads if possible.
Determining Final Requirements

Once total load is calculated and the appropriately sized generator is selected along with quantity and length of cables to each individual load, you will be able to determine what quantity and type of distribution panels you will need.

- 400A – 1200A I-Line panels to break down larger loads into smaller ones.
- 208V 200A 3PH Panels to break 3PH power into 1PH.
- 120V 50A 1PH panels to break 240V into 110V outlets.

Parallel Units

Parallel units could be required if...

- Your total load exceeds the capacity of a single generator.
- If redundancy is required (healthcare, data centers, other critical power scenarios).
- Live broadcasts will typically require parallel units to guarantee zero downtime or interruption.
- If the generator is required for redundancy or back-up purposes, do you need an ATS (automatic transfer switch)?
Additional Considerations

- Are multiple voltages required? You may want to consider a separate generator instead of a transformer.
- If voltage drop is a concern, you may also need to use a separate generator for that specific load. Be careful if you're trying to adjust generator output voltage to correct for V-drop.
- Fuel capacity vs. generator runtime. What refueling schedule is required?
- Keep away from building fresh air intakes or building overhangs.
- For longer rentals, consider PMS schedule.

Size Matters

Don’t get caught short

Dave Mansbart, ABLE Equipment Rental, Deer Park, N.Y.
Ohm’s Law

Generator Ratings

• Single-phase vs. three-phase
• What happens when you use the voltage selector switch
• 0.8 Power factor

Single-phase vs. Three-phase

Single-phase

Three-phase
Power Factor

Calculating Power Factor

Power factor = \( \frac{V_{\text{rms}} \cdot I_{\text{rms}} \cdot \cos \phi}{V_{\text{rms}} \cdot I_{\text{rms}} \cdot \text{Kd} \cdot \text{Kp}} \)

\( \text{Kd} = \) distortion factor (THD)  \( \text{Kp} = \) displacement factor (D.F)

\( V_{\text{rms}} = \) AC input rms voltage

\( I_{\text{rms}} = \) AC input rms current

\( I_{\text{fund}} = \) fundamental component of \( I_{\text{rms}} \)

\( \cos \phi = \) Phase angle between input AC voltage and the fundamental current

\( I_{\text{rms}} = \sqrt{I_1^2 + I_2^2 + I_3^2 + \ldots + I_n^2} \)

Power Factor – the easy way

What is Power Factor?

Sizing Considerations

- Types of loads
- Power factor
- Voltage drop
- Exhaust temperature
Voltage Drop

Exhaust Temperature

EPA emission tiers

Tier 4 Engines Produce 99% Less NOx and PM Emissions than Tier 3 Engines

So What’s Next.....
“Rule of thumb” definition

- **A rule of thumb** is an easy-to-remember guideline that is not necessarily a hard-and-fast rule or scientific formula but more than just a dumb guess
- **Oxford English Dictionary** first finds an instance of the phrase in 1692
  - “What he doth, he doth by rule of Thumb, and not by Art.” – Sir William Hope, *The compleat fencing-master*

Formulas and AMP Chart

Rules of Thumb

- Motor starting HP x 2 = kW
- Motor running HP x .74 = kW
- Sequence the largest motor to start first.
- UPS KVA x 3 = kW
- Lighting wattage x 125% = kW
- Tier 4 base load = 40% +/-
Generator Hazards and Best Practices

Shock or Electrocution

Hard wiring generators improperly can be deadly.

Electricity is the 2nd leading cause of death in construction.

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... non-fatal accidents yearly

... fatalities on average yearly due to electrocution

Leading Causes:

1. Drilling or cutting through cable
2. Failure to de-energize circuits and follow proper lockout/tag-out procedures
3. Failure to guard live parts from accidental contact
4. Moisture in the working area
5. Ground has failed
6. Fire hazards, whether an Arc flash or Arc blast

Shock or Electrocution

- Proper PPE
- Make sure that your generator has proper ground rod assembly; this is a must do!!!
- Always assume the generator has power running through it
- Do a dry run prior to turning on the power
- Check your numbers, make sure the load and all equipment match up
- Make sure you don’t overload generator, this can cause things to overheat or even catch fire
- Make sure all accessories are connected properly prior to operation; always check twice
- Make sure that your working area is hazard free
- Make sure all guards for any conductors are in place
Carbon-Monoxide or Air Contaminants

<table>
<thead>
<tr>
<th>% CO</th>
<th>ppm</th>
<th>CO Effects on Adults</th>
<th>100% Saturation is Blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1%</td>
<td>160</td>
<td>Slight Headache within 2 - 3 hrs</td>
<td>13%</td>
</tr>
<tr>
<td>0.2%</td>
<td>320</td>
<td>Mid-Headache, dizziness, sickness, weakness after 5 - 31 hrs</td>
<td>20-30%</td>
</tr>
<tr>
<td>0.4%</td>
<td>640</td>
<td>Headache to front of head, sickness after 1 - 2 hrs, Risk of Life after 3 hrs</td>
<td>50%</td>
</tr>
<tr>
<td>0.6%</td>
<td>960</td>
<td>Severe headache, dizziness, confusion within 5 minutes, unconsciousness with possible fatal consequences within 1 - 7 hrs</td>
<td>50%</td>
</tr>
<tr>
<td>0.8%</td>
<td>1280</td>
<td>Headache, dizziness &amp; sickness, within 5 - 10 mins, Unconsciousness with fatal consequences within 10 mins.</td>
<td>70 - 75%</td>
</tr>
<tr>
<td>1%</td>
<td>1600</td>
<td>Immediate medical symptoms, Fatal consequences within 1 - 2 mins. Avoid too near</td>
<td>80 - 90%</td>
</tr>
</tbody>
</table>

Fire Hazards

- Cleanliness plays a huge role
- Make sure all circuits and breakers are working properly and fail-safes are in working order
- Overloading can cause overheating and possible fire
- Always know where your closest fire extinguisher is located
- PPE

Noise Decibels

- Knowing output of machine
- Lawn Mower is generally about _______ dB
- In general sounds above _______ dB are harmful
- Make sure if in contained area you know dB levels
- Make sure that all doors on generator are shut while in operation
- If above the dB level of negative exposure, make sure hearing protection is provided or recommended
Proper Towing

- Make sure all components are right sizes, hitch and ball or pintle hitch is appropriate size, classified correctly to trailer and hitch towing regulations.
- Make sure that towing vehicle is suitable for generator size, make sure to account for fuel weight (6.9 lbs/gallon of fuel)
- Make sure safety chains, pins and latches are all present and in working order.
- Make sure that all of your tires are checked and in working order prior to delivery or will call.
- Make sure all door and panels will shut and open without becoming a hazard while towing.
- Like any other trailer make sure that all lights are functional and signals are clean and in working condition.

Use of Safety Accessories

Maintenance
Cleanliness

- Make sure that the machine is clean, most importantly any flammable or combustible fluids left over from servicing.
- Make sure that you use only non-combustible cleaners.
- Clean and tight connections on generator outlets, make sure they are not too tight or loose.
- Be sure all accessories items are also clean of debris and are in working order.
- Make sure you don’t spray water directly on to panels, make sure they are clean and dry upon rental.

Proper Function of Outlets and Breakers

- Make sure that your GFCI outlets actually work by testing prior to rental; there are several different GFCI testers that make this an easy process.
- Along with the outlet check your temp boxes and panels GFCI outlets.
- Test breakers and output on all outlets to make sure all circuits will work properly.
- Test the load with approved tester according to manufacturer standards.
- Make sure that when testing any outlets proper PPE is worn.

Time for Questions

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