CAPITAL PARTNERS

"CLIF NOTES" SERIES

(Competent Leveraging of Information and Facts)

ELECTRICAL

What basic information do you need to know about electrical systems in buildings and why? The Capital Partners' ***Electrical CLIF Notes*** will provide you with the buzz words, general definitions and description of the basic components of common electrical systems. You will now have enough information to be dangerous, yet still impress your clients and colleagues.

COMMON TERMS

AC – Alternating current. Standard electrical current used in commercial and residential construction. Power companies generate alternating current to make transmission of electricity over long distances more efficient. In the United States, AC is delivered at frequency of 60 hertz (cycles per second).

DC – Direct current. Most commonly encountered in batteries (uninterruptible power supplies, automobile application, and photovoltaic/solar generation).

AC/DC – a popular heavy metal band of the 70's & 80's that used a lot of electricity during their concerts.

Amp (Ampere) – a unit of measure for the amount of electrical current that flows through a circuit (wire).

Back-up Generator – This is a source for back-up power to run mission-critical operations in the case of a power outage. These generators are most commonly powered by a diesel engine that stands ready to run when a sensor tells it that the power is out. Regular testing, maintenance and fueling are necessary to insure the system is operational when needed. The sizing of the generator is calculated in much the same way as building load: it is determined by equipment you need to run and for how long. Since back-up generating systems can be expensive; most companies choose to have only a small amount of their most critical systems on the back-up circuit and to have the generator specified to run for only a short period of time. There are new natural-gas fired units that are increasing in popularity because they eliminate the need for a fuel tank and are plumbed directly into the building's natural gas service. A flaw to the natural gas fed generator is when both the electrical and gas services are interrupted.

Buss – the portion of the main switchgear through which current is transmitted, usually a piece of copper or aluminum bar mounted to the switchgear.

Buss Duct – a system for connecting equipment (much like a power strip) that replaces feeder wire and conduit. It is used in applications where a high level of distribution and future modifications will occur (computer rooms, manufacturing floors).

Buss Fed – when a main electrical service size exceeds 2500 amps, a buss connection (solid copper or aluminum bar) must be made from the transformer to the main switchgear.

Circuit – Two or more wires that electricity flows from the source through a device (equipment, etc.) and back to the source.

Circuit Breaker – Safety switch installed in circuit to break electricity flow automatically when current exceeds a predetermined amount. Circuit breakers are like fuses but they can be reset once "tripped". Standard circuit breaker sizes (in amps) are: 15, 20, 25, 30, 35, 40, 50, 60, 70, 80, 90, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 600, 800, 1000, 1200, 1600, 2000, 2500, 3000, 3500, 4000, 5000, 6000.

CT – Current transformer used to measure current via a low-voltage metering device. CT's are used in conjunction with the utility meter to measure utility usage.

Current – The movement of electrons through a conductor (wire, buss, etc.); measured in amperes, mill amperes, and microamperes.

Foot-candles (FC) – A unit of measure for light (the amount of light produced by one 12" candle measured one foot away the flame). Standards have been established for many different applications. (Please see Rules of Thumb below for typical foot-candle levels)

Foot-candle Levels: (Average Maintained)

Offices: 35-50FC

(35 FC are used where indirect lighting is used while 50 FC are generally acceptable in 2x4 fluorescent lighting applications) You can plan on 1ea. 2x4 fixture per 65-80 sq. ft. depending on the amount of private office vs. open office. The higher the percentage of private office you should plan on using 1ea. fixture per 65 sq. ft.

Corridors: 20-25 FC

Typical corridors require one downlight every 8-10 ft. while 2x2 or 2x4 fluorescent fixtures can be spaced 10-12 ft.

Lobbies:20-30 FC

Light spacing depends on the amount of decorative lighting used. Typical lobbies include a mixture of pendant lighting, downlighting, and wall sconces.

Parking Lots: 1FC Minimum (Many localities require this by code)

Parking lot poles can be typically spaced based on 1.5 times the mounting height in the "Y" direction and 4.5 times the mounting height in the "X" direction. "Y" direction is defined as the direction the fixture is pointing while the "X" direction is the side to side direction.

Ground – A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

GFI (Ground-Fault Interrupter) – A protective device that functions to shut off a circuit within an established period of time when a short (current to ground) exceeds some predetermined value. A simple version of this is the electric outlet in most bathrooms and kitchens by the sink that has the button built in to reset the circuit.

kVA – Kilovolt amps (1000 volt amps). You'll sometimes encounter this reference in the sizing of back-up generators (50 kVA, 75kVA).

kV – Kilovolt (1000 volt amps). You'll usually encounter this reference in discussions about the sizes of main power transmission lines (i.e., 12 kV or 60 kV). Large kV transmission line 60kV are too cost prohibitive to underground.

kW – Kilowatt (1000 watts).

kWH – Kilowatt Hour. One kilowatt hour equals 1,000 watts of power used for one hour (the amount of power to run 10, 100-watt light bulbs for one hour).

Load/Building Load - The total amount of amps of power needed to run the equipment in a building (see methods of calculation below).

Main Service Switchboard (aka, main panel) - Usually consists of the main circuit breaker or switch and the utility meter for the entire facility. This equipment is usually located in an enclosed electrical room near the utility transformer. The switchboard/main panel is the main electrical control and means of cutoff of the power supply to a building.

Multi-Metered Main Service Switchboard – This is the same as a Main Service Switchboard (see above) except that it provides multiple main circuit breakers or switches and the utility meters for multiple areas within a facility. This is typically used in multi-tenant buildings where each tenant needs its own electrical use metered separately. This equipment is usually located in the electrical room near the utility transformer.

Ohm – The unit of electrical resistance used to measure the resistance or loss of power as it passes through a conductor.

Photovoltaic System (PV) – Solar panel, power inverter (DC to AC), and battery back-up that work as a system to convert solar energy into electrical energy suitable for connection to a building load. Photovoltaics are gaining more ground in the industry as rebates from the government are beginning to make them more cost effective. Consult an Electrical Engineer if you encounter a requirement for this type of system.

Primary vs. Secondary Service – "Primary" service users buy and receive power from the utility company at high voltage (12 kV or higher) and the user buys and owns their own transformer. Most users are "secondary" users where the utility company owns the transformer and delivers power stepped down to 208V or 480V. Heavy power users may find reduced utility rates as a benefit of selecting primary service.

Service Entrance – the location in the building where all electrical service is initially brought into the building. Typical the service entrance is as close as possible to the power company's power source.

Single-Phase & Three-Phase Service – This refers to the way power is delivered to a building. Single phase has a current wire and a neutral ground-wire. Three phase is delivered with three current wires and a neutral ground-wire. Most commercial applications are three phase and most residential applications are single phase because equipment in commercial buildings (HVAC equipment, elevators, and production/manufacturing equipment) is almost always configured to run on three phase power allowing these heavier loads to distribute current between three wires instead of one, reducing the size of the wires needed and therefore, the cost of installation. The phase information can usually be found on the nameplate on the front of the main service switchboard or inside the panelboard door.

Subpanel/Panelboard - A single panel or group of panel units that house the circuit breakers for the control of lights, HVAC equipment and other power circuits. Subpanels/panelboards are placed against or hung on a wall and are accessible only from the front. These can either be installed in the electrical room near the main panel or distributed throughout a facility to be located closer to the equipment they are servicing.

Switchgear - The main circuit breaker (see main service switchboard above) housed in the electrical room that provides the main shut-off for a building.

Tenant Meter - An in-line, privately-owned meter that allows for measuring of a tenant's power consumption if they are on a common service with other tenants in a building.

Transformer - Equipment that is used to transform (step down) power from a higher voltage (i.e. 480V) to a lower voltage (208V) to run common electrical appliances and equipment that cannot run on high voltage

UPS – Uninterruptible power supply. This, like a back-up generator, is precautionary equipment in the event of power interruption. However, UPS are not designed to run equipment, but rather to provide stop-gap power to allow for an orderly shutdown of computer equipment so that data stored in memory is not lost. UPS systems are wired into a building's electrical system on certain critical circuits and are essentially batteries. There are also less sophisticated UPS systems that are standalone devices that are connected directly to computer equipment.

Volt – A unit of measure for the amount of force of the current flowing through a circuit. Think of it in terms of the water pressure in a hose. Volts = pressure and Amps = volume

Voltage – A numeric value assigned to a circuit or system based on the equipment loads and cost effective design. Typical voltages for building uses are 120V, 208V, 277V, 480V. Voltage level is most often determined by what type of equipment/lighting and HVAC loads the user intends to run and the size of the facility (see Sample Load Calculation below).

Typical voltages for transmission lines (either overhead or underground power lines) are 4,160V, 12kV, 21kV, 60kV. Power is generated at high voltage and is therefore transmitted at those voltages and not further processed until closer to the end user.

Also, the higher the voltage, the lower the current when power remains constant which allows for a smaller wire/conductor size.

Volt Amps (VA) - For purposes of this discussion assume watts and VA are equal. But for the inquisitive and "techy" type individuals, Watts and VA are really not equal. Watts = Power Efficiency Factor x VA. An 80-90% power efficiency factor is usually assumed for commercial loads. For intensive industrial facilities with large amounts of motor loads, this factor can be drastically skewed.

Watts (W) - A unit of measure equal to a current of one amp (volume) at a force of one volt (pressure). Most electrical equipment are rated in watts according to the power they consume (example: 100 Watt light bulb).

COMMON QUESTIONS

When people say "110" or "120" or "220" or "240" or "440" or "460" or "480", what do these voltage ratings mean? In residential applications "120" is the correct designation (single phase due to a 240 volt single phase service) although we refer it as "110". "120" ("110") is the single-phase voltage on a 208 volt system. "220" refers to an older voltage rating typically taken from residential appliances like electric dryers or ovens. "240" is accurate standard voltage at which power is delivered by the utility company for a residence. There is no such voltage as "440" … should be "460". "460" is the voltage typically spec'd for mechanical equipment or motor loads. "480" is the most common voltage at which power is delivered by the utility company for commercial applications.

Service Size defined:

110/208 – 3-Phase 4 Wire (Standard)

- 120 volts single phase from a 208 volt panel is obtained by using single phase wiring (one hot and one neutral wire)
- 208 volts single phase from a 208 panel is obtained by using (two hot wires NO neutral)
- 208 three phase (three hot wires, NO neutral)
- Good for small offices and residential.

277/480 – 3-Phase, 4-wire (Standard)

- 277 volts single phase from a 480 volt panel is obtained by using single phase wiring (one hot and one neutral wire)
- 480 volts single phase from a 408 panel is obtained by using (two hot wires NO neutral)
- 480 three phase (three hot wires, NO neutral)
- Great for heavy equipment and distributing lots of power to other parts of the building. You will need a step-down transformer to reduce the voltage to 120 volts for typical office equipment.

But how much power do I really need? You need to start with what equipment you plan to operate in and around a building including all office/shop equipment, lighting (both interior and exterior), HVAC equipment and any other device or equipment that runs off of electricity. You can then determine how much of this total "load" would likely be needed on average at a given point in time. Then most people elect to upsize the service by a 20% buffer factor. All of this totaled up is referred to as "building load".

Rules of Thumb:

Average watts/sq. ft. used for office space:	18.5 watts per sq. ft.
Average watts/sq. ft. used for warehouse space:	5-7 watts per sq. ft.
Average watts/sq. ft. used for warehouse space with HVAC:	12-15 watts per sq. ft.
Average watts/sq, ft. used for Dry Goods Retail Space:	18-20 watts per sq. ft.
Average watts/sq. ft. used for Retail Space with Restaurants:	22-35 watts per sq. ft.
Average watts/sq. ft. used for Call Center:	20-25 watts per sq. ft.
Average watts/sq. ft used for Data Center:	45-65 watts per sq. ft.

(Averages include typical lighting, power, HVAC, elevator, site lighting loads and 20% spare capacity)

Sample Load Calculation for Typical Office Building:

Assume: 100,000 sq. ft. office facility

100,000 sq. ft. x 18.5 watts/sq. ft. = 1,850,000 watts

Determine Service Entrance Circuit Breaker Ampacity at 208V 3-phase:

1,850,000 / 360 V = 5,138 A

Use 6000 amp service at 120/208V 3-phase (Ampacity based on Circuit breaker sizing above. (360=208 x square route of 3)

Or

Determine Service Entrance Circuit Breaker Ampacity at 480V 3-phase

1,850,000 / 831 V = 2,226 A

Use 2500 amp service at 277/480V 3-phase (Ampacity based on Circuit breaker sizing above. (831=480 x square route of 3)

Solution: For a 100,000 sq. ft. facility, a 2,500 amp service at 277/480V 3-phase, service will, in most instances, be the most cost effective solution.

This same analysis can be completed for various types of buildings based on the rules of thumb outlined above. Residential facilities, apartment houses, assisted living facilities, and hotels require a much more complex analysis. The number of dwelling units versus the amount of public space can significantly affect the voltage and ampacity selection.

What does it typically cost per square foot for electrical service for:

Space Type	SMUD Territory Per SF Per Month	PG&E Territory Per SF Per Month
Office area	$ 0.15	$ 0.20
Warehouse area (unconditioned)	$ 0.02	$ 0.03
Warehouse area (conditioned)	$ 0.05	$ 0.08

Note: depends on time of usage, equipment demand load and equipment efficiency

What is a rule of thumb for the cost per for 1000 amps of service size at 110/208v? 1000 amps would cost $29,000; **at 277/408v?** 1000 amps would cost $33,000. You can extrapolate the cost up or down in both cases. Beyond this, to increase the size of service, you can figure an additional 100 amps at 110/208v costs about $800 and about $1000 at 277/408v.

What is it about electricity and electrical equipment that makes it dangerous? Electricity wants to find its path of least resistance to ground. There is basically no resistance in water. Since the human body is made up largely of water, electricity would rather travel through you to ground than a wire. What makes electricity even more dangerous, is that you can't see or smell it.

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A Special Thanks! *Most of this information was provided by Bill Hubbard of Rex Moore Electric, Inc. They are available to assist you and your clients with all of their electrical questions and needs from system design and installation to maintenance and repair.*

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