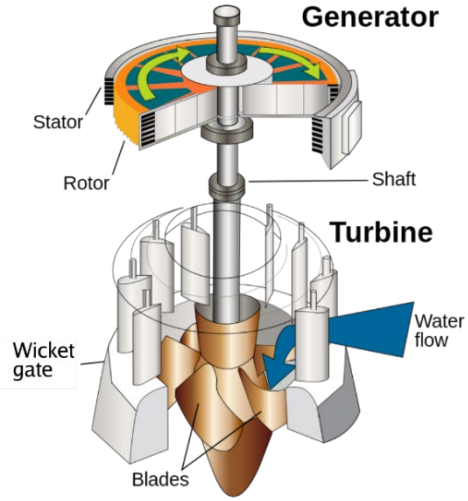
Power Distribution

Power Generation

- ☐ Electricity generation is the process of generating electrical energy from other forms of energy.
- ☐ Almost all electrical power on Earth is generated with a turbine of some type.
- ☐ Turbines are commonly driven by wind, water, steam or burning gas.
- ☐ The turbine drives an electric generator.
- ☐ A generator converts mechanical energy into electricity by magnetic induction.

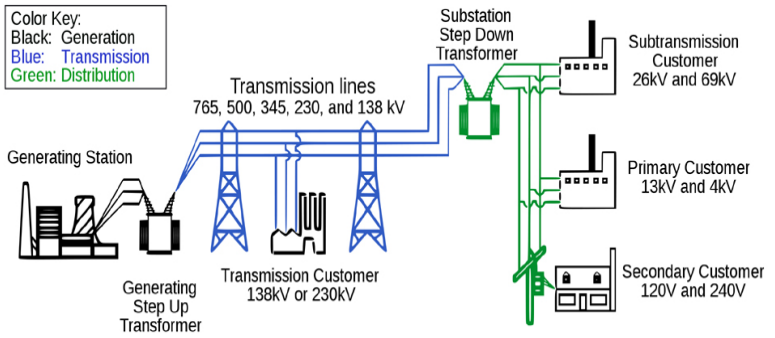


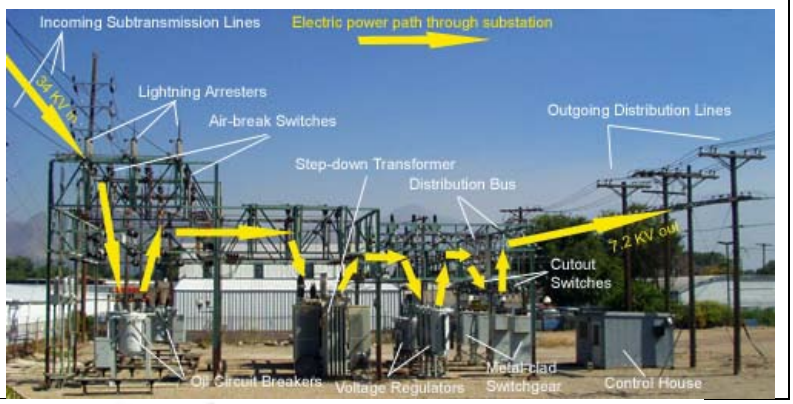
Power Transmission Lines

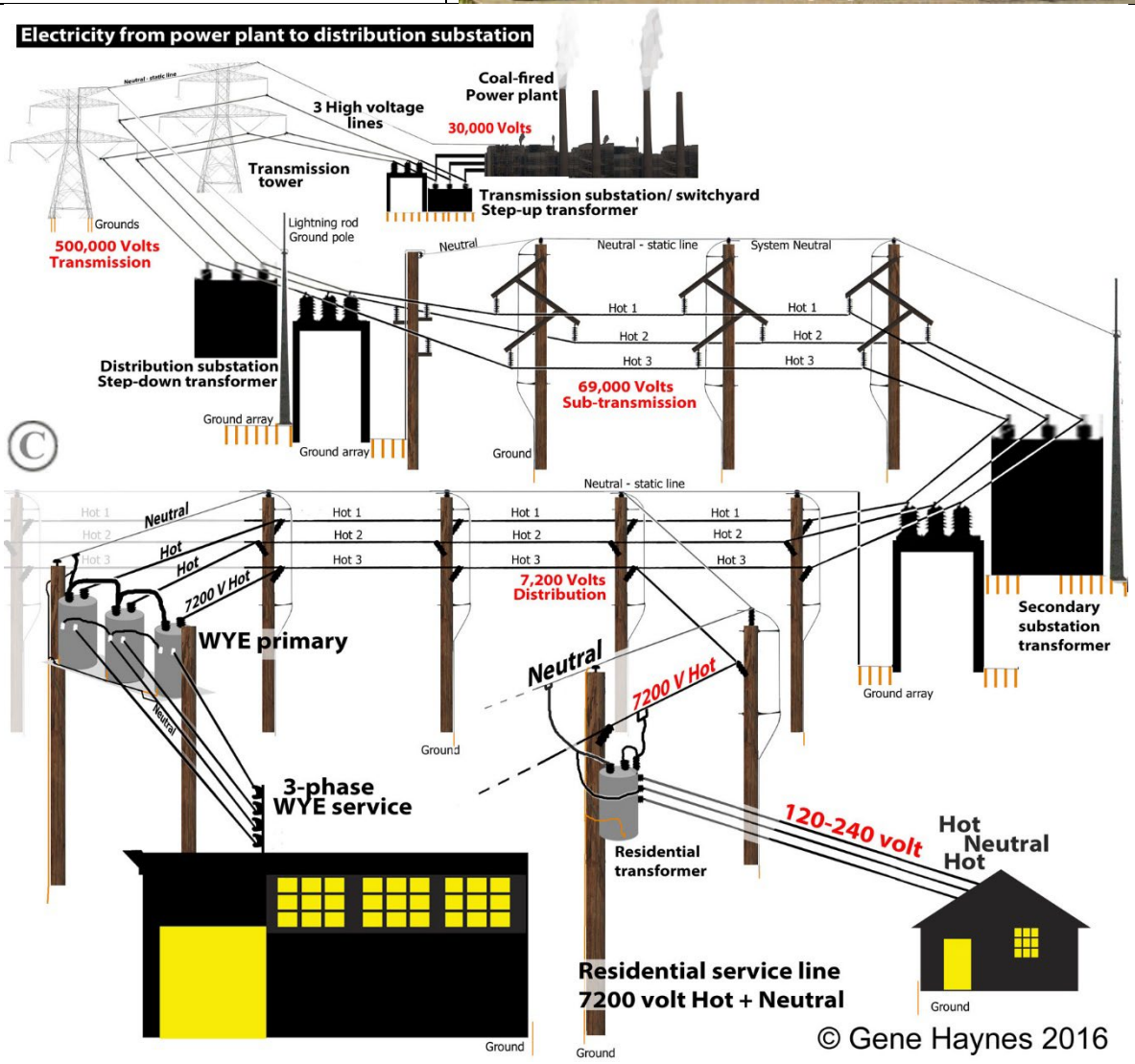
- ☐ Transmission lines are sets of wires, called conductors, that carry electric power from generating plants to the substations that deliver power to customers. At a generating plant, electric power is “stepped up” to several thousand volts by a transformer and delivered to the transmission line.

Power Generation and Transmission

- ☐ The type of transmission structures used for any project is determined by the characteristics of the transmission line's route, including terrain and existing infrastructure.
- ☐ This is distinct from the local wiring between high-voltage substations and customers, which is typically referred to as ***electric power distribution***.
- ☐ At numerous substations on the transmission system, transformers step down the power to a lower voltage and deliver it to distribution lines. Distribution lines carry power to customers.
- ☐ The combined transmission and distribution network are known as the "power grid" in North America, or just "the grid".



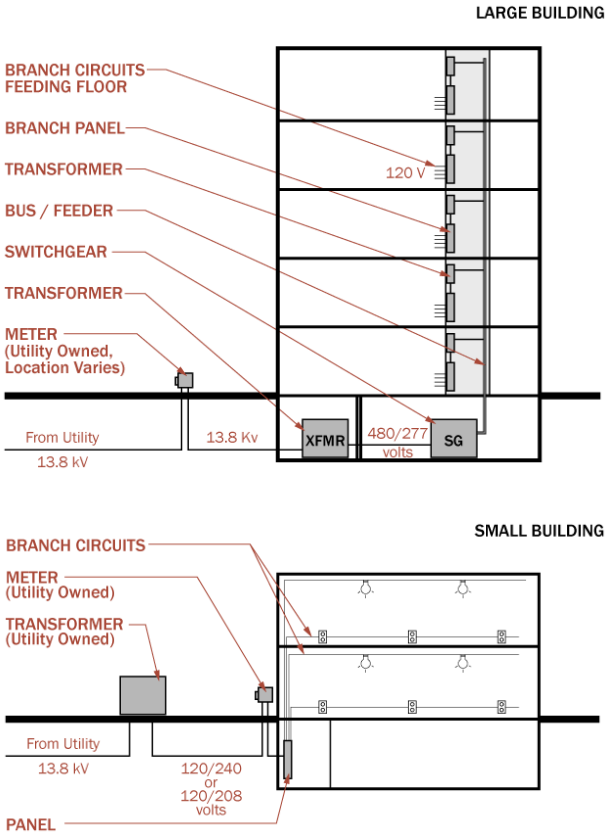




Low Voltage Distribution Equipment

Table 4-1: Standard nominal three-phase system voltages per ANSI C84.1-1989

Voltage Class	Three-wire	Four-wire
Low Voltage		208 Y/120
	240	240/120
	480	480 Y/277
	600	
Medium Voltage	2,400	
	4,160	4,160 Y/2400
	4,800	
	6,900	
		8,320 Y/4800
		12,000 Y/6,930
		12,470 Y/7,200
		13,200 Y/7,620
	13,800	13,800 Y/7,970
		20,780 Y/12,000
		22,860 Y/13,200
	23,000	
		24,940 Y/14,400
	34,500	34,500 Y/19,920
	46,000	
	69,000	
High Voltage	115,000	
	138,000	
	161,000	
	230,000	
Extra-High Voltage	345,000	
	500,000	
	765,000	
Ultra-High Voltage	1,100,000	



Service Equipment

NEC Article 100 Definitions

Service Equipment - The necessary equipment, usually consisting of circuit breakers or switches and fuses and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply. Service equipment does not include the metering equipment, such as the meter and/or meter enclosures.

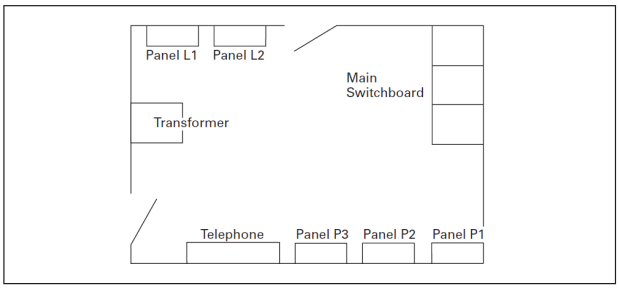
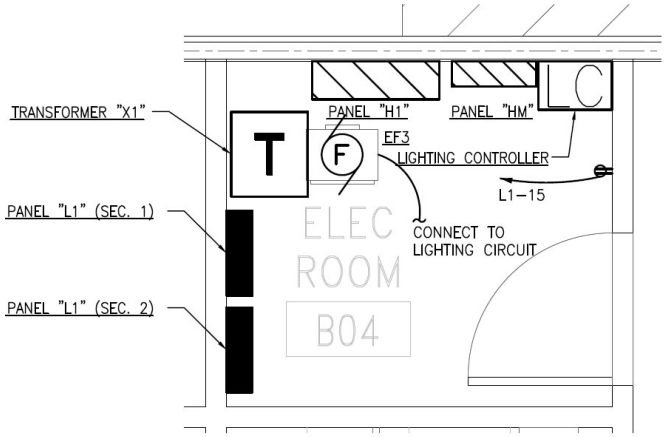


Figure 21.6-1. Traditional Electrical Room—Plan View



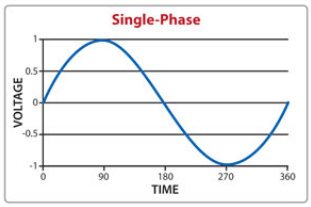
PARTIAL PLAN - ELECTRICAL ROOM
SCALE: 1/2" = 1'-0"

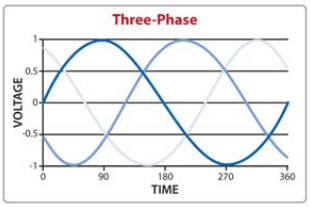
Typical Electrical Distribution Equipment

Switchboards and switchgear
Electrical panelboards – Lighting / Power / Equip.
Transformers
Lighting Control Panel
Disconnect Switches
Motor starters and motor control centers (MCCs)

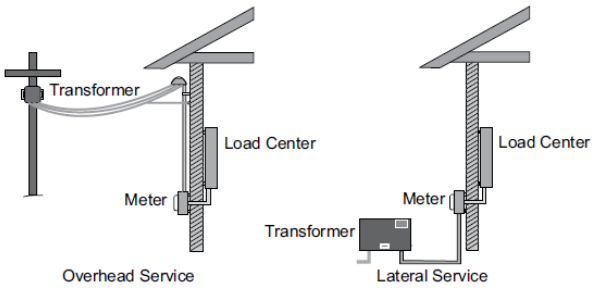
Incoming Service – Power

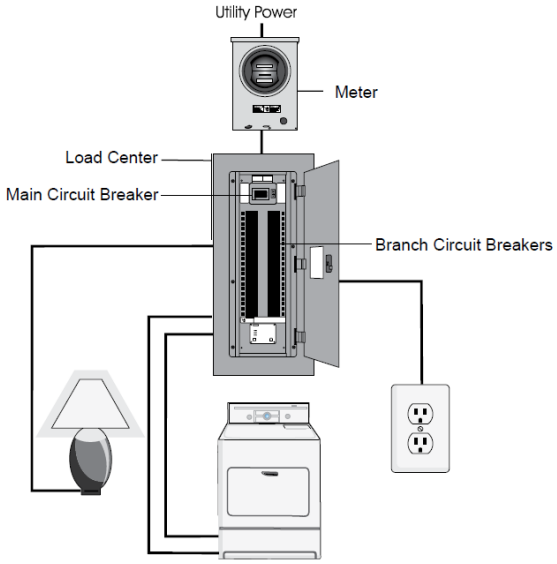
- ☐ All buildings have an electrical service.
- ☐ A utility transformer is installed outside the building on a pad (site drawing) or pole.
- ☐ Primary service (utility company) is shown on the One-line Diagram, Single-line Diagram, or Riser Diagram.



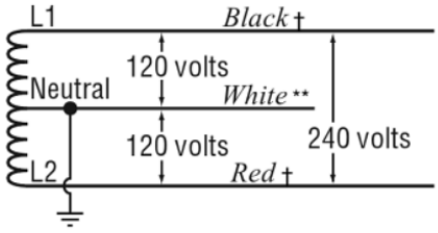


Common Electrical Distribution Systems
Residential
Incoming Service Voltage

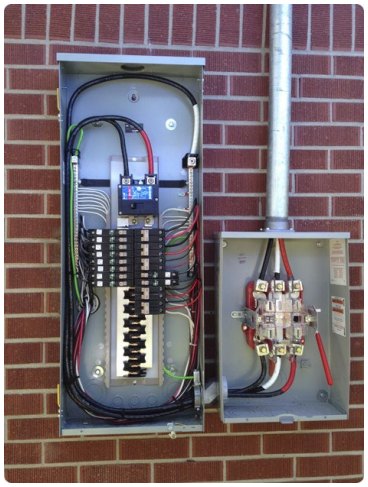




120/240-Volt, Single-Phase, Three-Wire System



† • **Line one** ungrounded conductor colored **black**
† • **Line two** ungrounded conductor colored **red**
** • Grounded neutral conductor colored **white** or gray

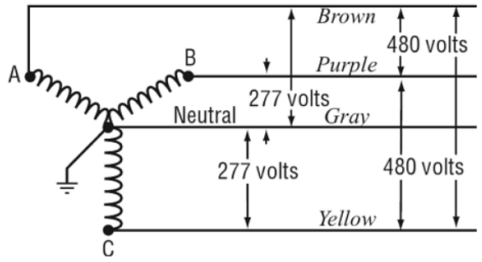


Commercial / Industrial

Incoming Service Voltage

The most common commercial building electric service in North America is 120/208-Volt wye, which is used to power 120VAC plug loads, lighting, and smaller HVAC systems. In larger facilities the voltage is 277/480-Volt and used to power single phase 277VAC lighting and larger HVAC loads.

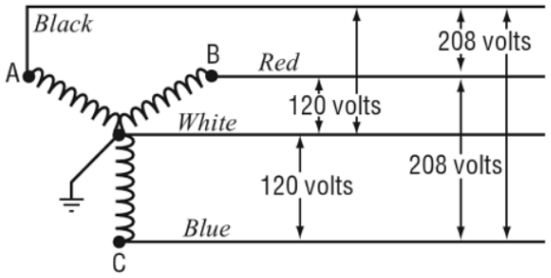
277/480-Volt, Three-Phase, Four-Wire System (Wye Connected)



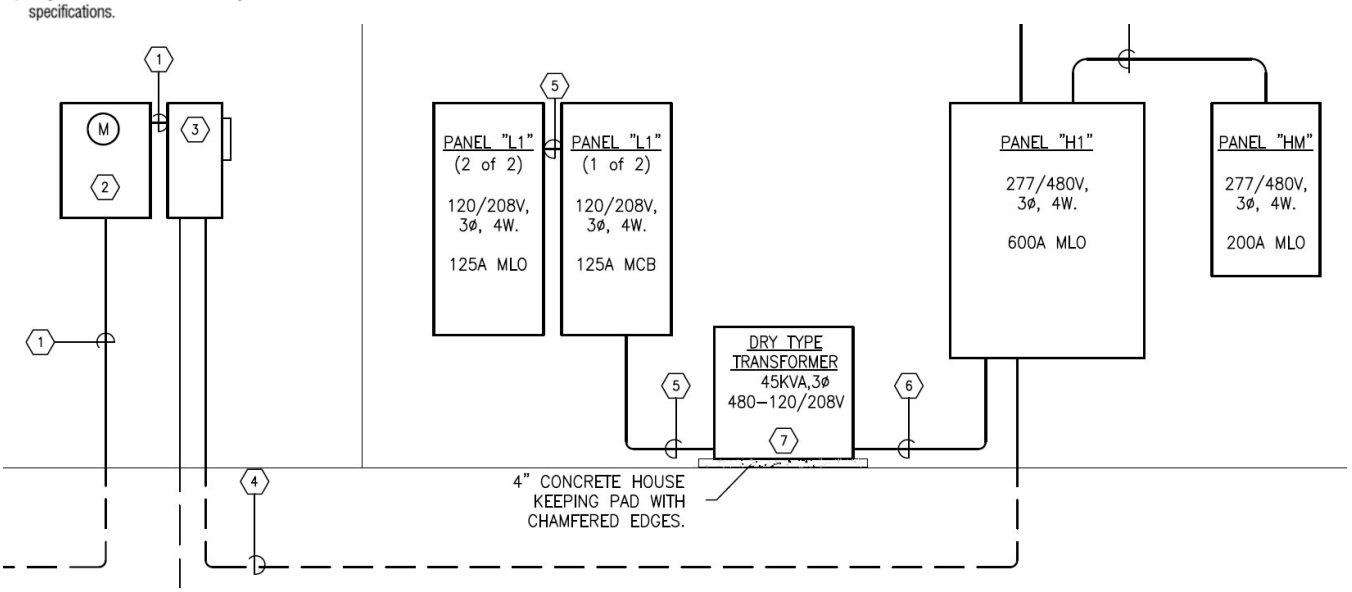
† • **A** phase ungrounded conductor colored **brown**
† • **B** phase ungrounded conductor colored **purple**
† • **C** phase ungrounded conductor colored **yellow**
** • Grounded neutral conductor colored **gray**

** Grounded conductors are required to be white or gray or three white stripes. See *NEC* 200.6(A).
* B phase of high leg delta must be orange or tagged.
† Ungrounded conductor colors may be other than shown; see local ordinances or specifications.

120/208-Volt, Three-Phase, Four-Wire System (Wye Connected)

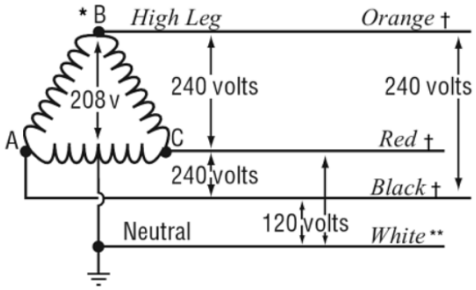


† • **A** phase ungrounded conductor colored **black**
† • **B** phase ungrounded conductor colored **red**
† • **C** phase ungrounded conductor colored **blue**
** • Grounded neutral conductor colored **white** or gray



Uncommon Electrical Service

120/240-Volt, Three-Phase, Four-Wire System (Delta High Leg)



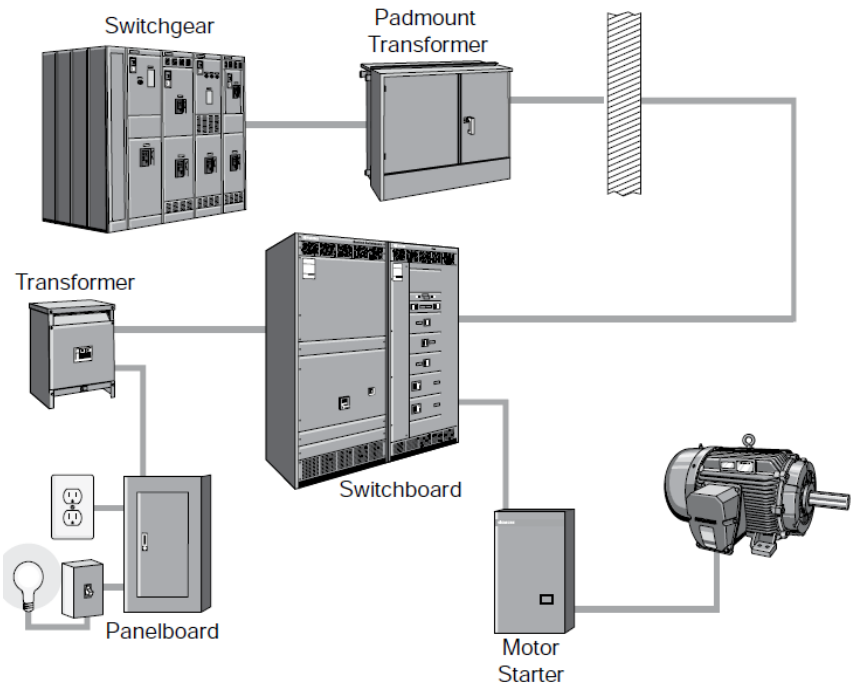
† • **A** phase ungrounded conductor colored **black**
†* • **B** phase ungrounded conductor colored **orange** or tagged (High Leg). (Caution - 208 V orange to white)
† • **C** phase ungrounded conductor colored **red**
** • Grounded conductor colored **white** or gray (Center Tap)

Also known as a high-leg or wild-leg delta system. Used in older manufacturing facilities with mostly three-phase motor loads and some 120VAC single-phase lighting and plug loads.

Similar to Three Phase Three Wire Delta but with a center-tap on one of the transformer winding to create neutral for 120VAC single-phase loads.

Motors are connected to phase A, B, and C, while single-phase loads are connected to either phase A or C and to neutral. Phase B, the high or wild leg, is not used as the voltage to neutral is 208VAC.

Commercial and Industrial Power Distribution Equipment



Switchgear may or may not be part of the distribution system.

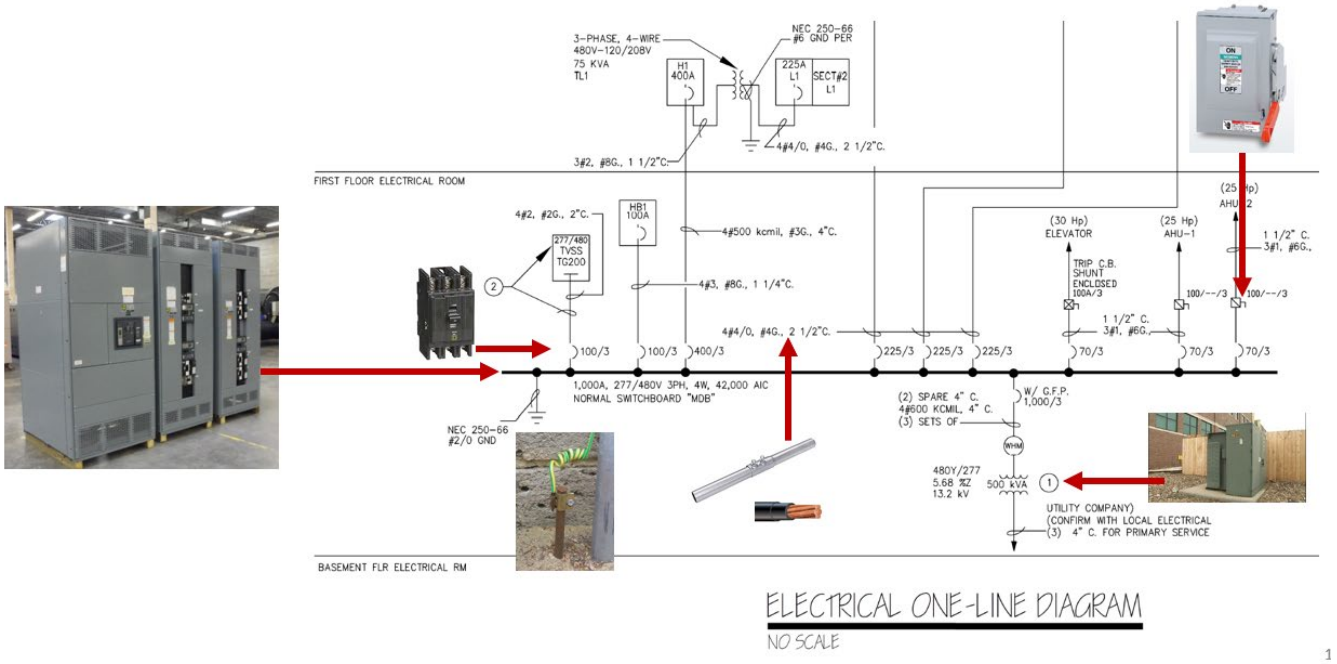
It is typically present if the incoming power provided by the utility company is at a much higher voltage level than the commonly supplied 277/480-volt.

The owner purchases a higher voltage level (5kV, 13.8kV, 15kV) and purchases and maintains the switchgear and step-down transformer(s).

Switchboards are generally for voltages less than 600 volts. They are free standing and intended to be accessible from the front and rear.

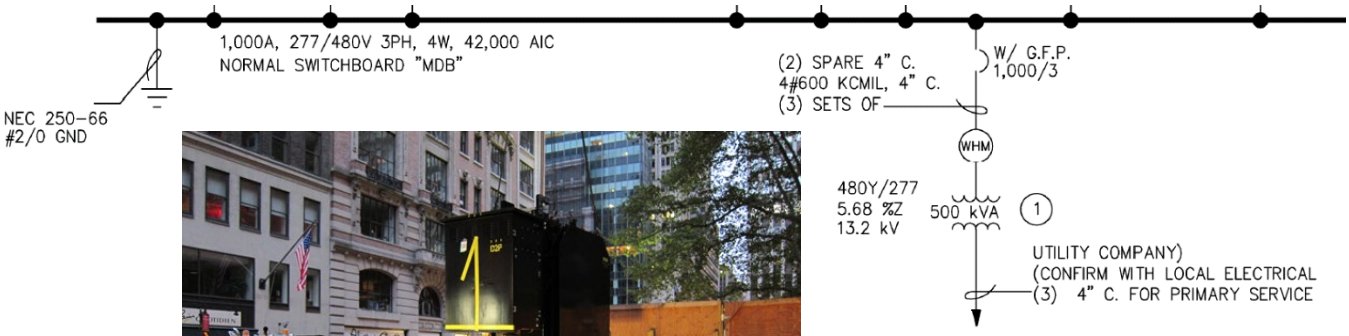
Electrical One-Line Diagram

Drawings or schematics that describe a building's electrical design are usually referred to as single-line diagrams because all the wires (i.e. 3-phases, neutral, and ground) are represented by a single line connecting all the major components such as; power panels, lighting panels, motor control centers, transformers, disconnects, and building equipment. The one-line may also be shown as a riser diagram.



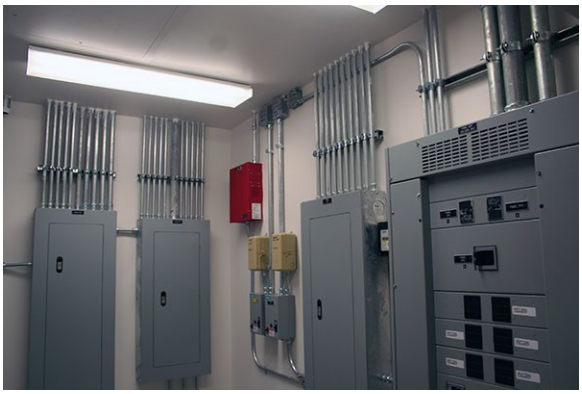
Utility Primary Transformer

The power provided to a building all starts at the utility primary transformer. The secondary of the transformer is connected to the switchgear, switchboard, or a panel. The power company “owns” and connects the primary service. The EC connects the secondary to the building distribution.

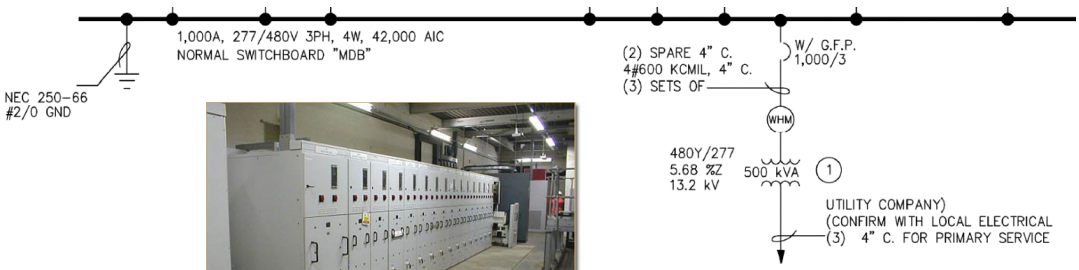


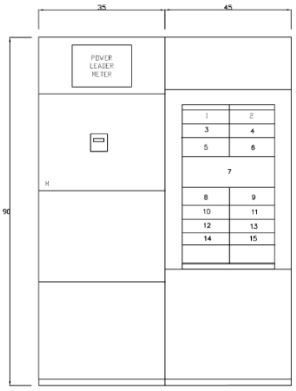
In-Coming Service – Power

Power Distribution System Equipment



Switchboard
Main Distribution Board (MDB)
Main Switchboard (MSB)





SWITCHBOARD DETAIL N.T.S.
1000A 277/480V 3PH., 4W 42,000 AIC

Sections of a Switchboard

- ☐ Incoming Section
- ☐ Meter Main Section
- ☐ Distribution Section
  - Circuit Breakers (CB)
  - Fusible Switches
- ☐ Grounding
- ☐ Bonding

Circuit Breakers

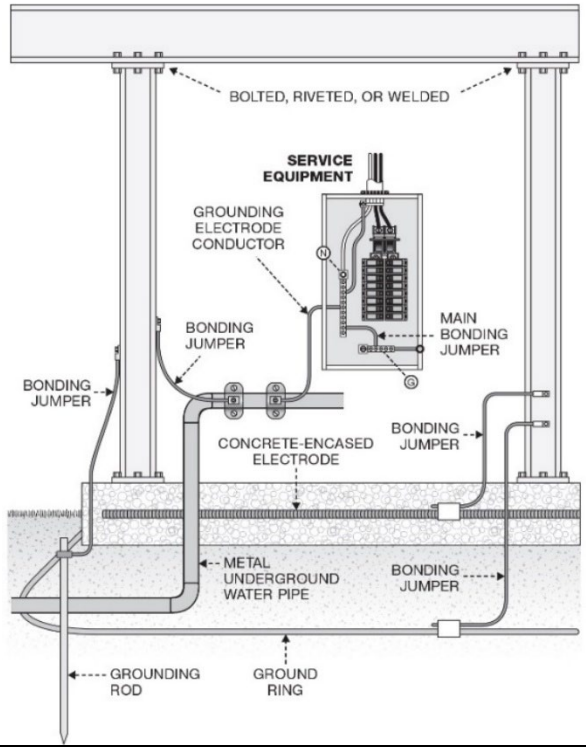
- ❑ A circuit breaker is a switch that automatically interrupts electrical flow in a circuit in case of an overload or short.
- ❑ The three types of circuit breakers:

		
Standard	GFCI	AFCI

3-Pole CB
The 3-pole circuit breaker is used for three-phase circuits where there is L1, L2, L3 and N wire.

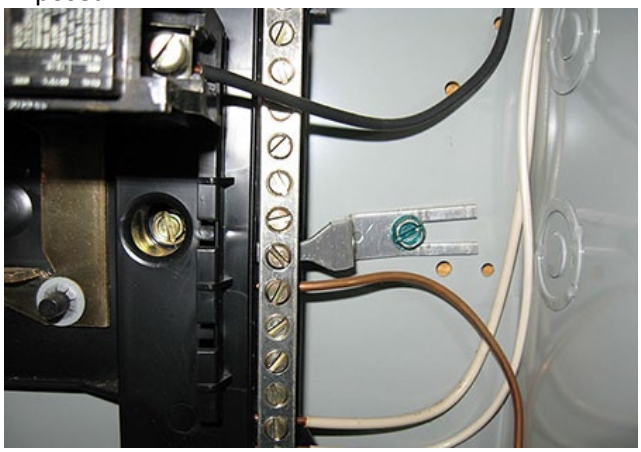
Grounding

Article 100 of the NEC defines grounding as, "Establishing a 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."



Bonding

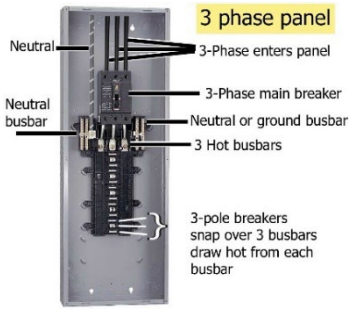
The NEC defines bonding as, "The permanent joining of metallic parts to form an electrically conductive path that ensures electrical continuity and the capacity to conduct safely any current likely to be imposed."



Panelboard

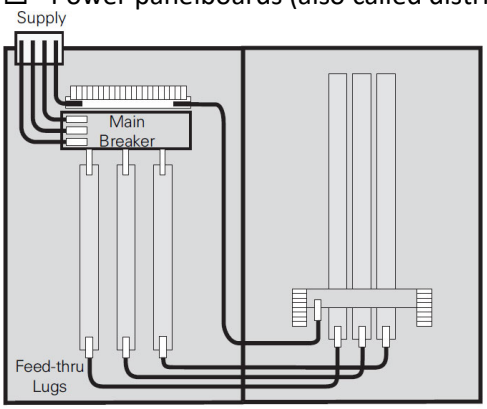
NEC® definition, panelboards are:

- ☐ Used to control light, heat, or power circuits
- ☐ Placed in a cabinet or cutout box
- ☐ Mounted in or against a wall
- ☐ Accessible only from the front

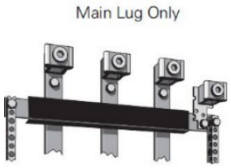


National Electrical Code® Article 408, Switchboards and Panelboards. Panelboards are frequently divided into two categories:

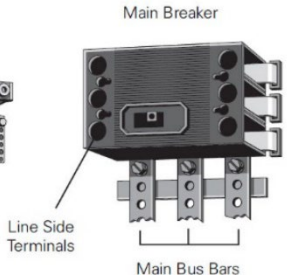
- ☐ Lighting and appliance branch-circuit panelboards
- ☐ Power panelboards (also called distribution panelboards)

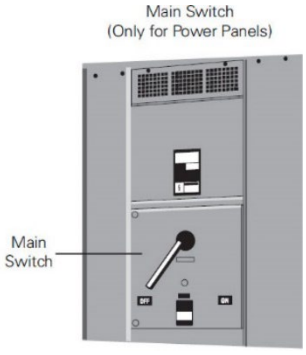


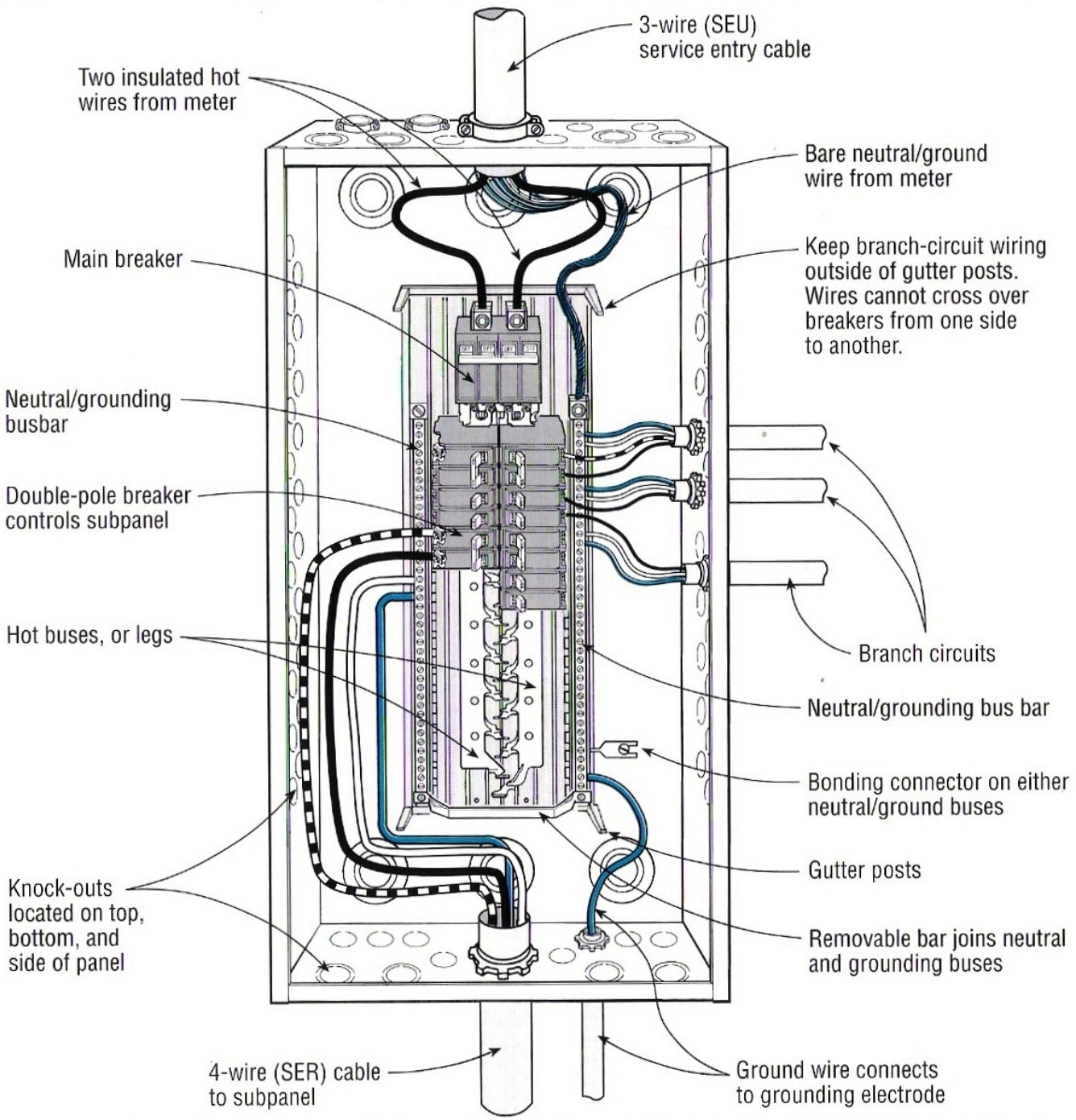
Main Breaker Panelboard — MCB



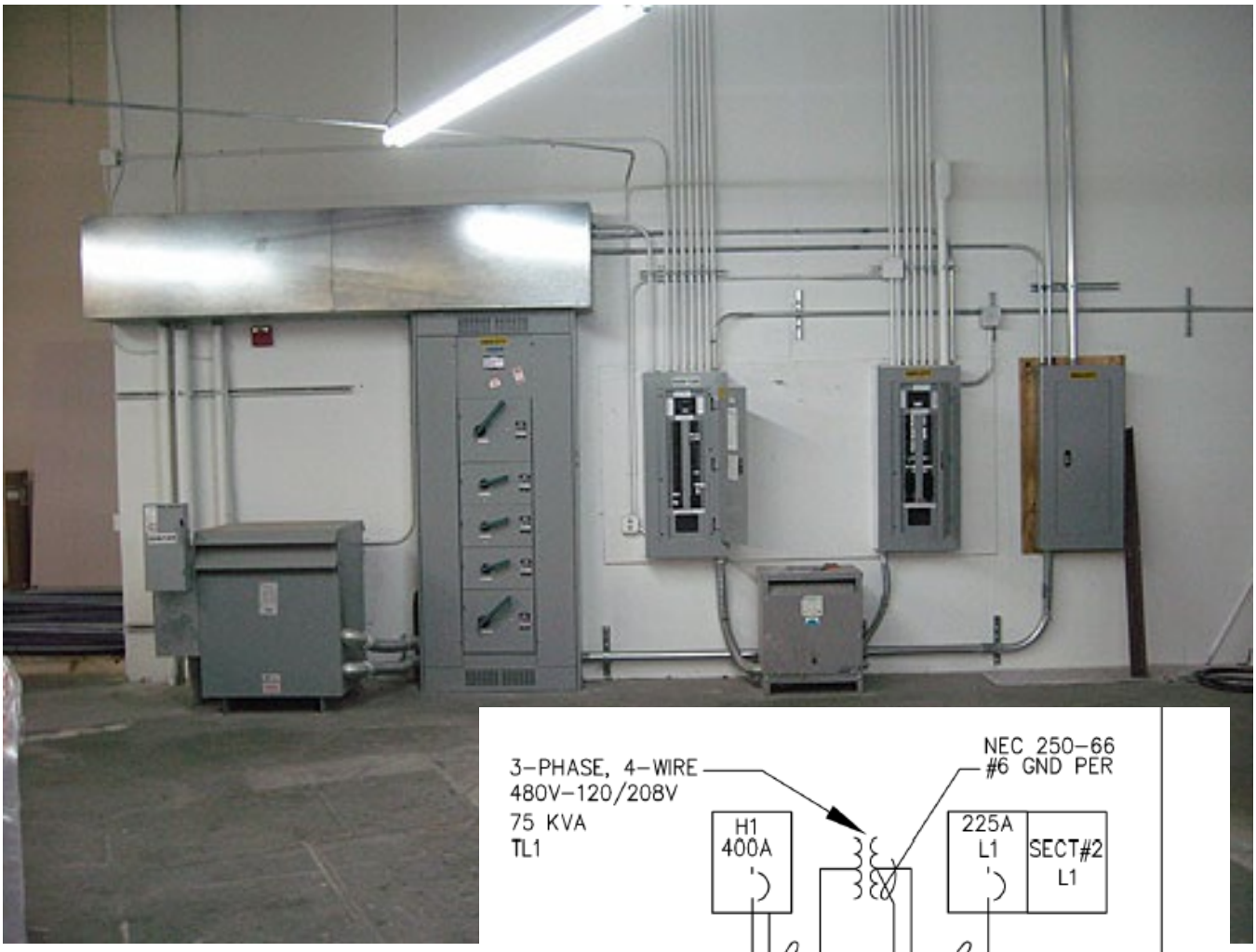
Main Lug Only Panelboard — MLO






3-wire (SEU)
service entry cable
Two insulated hot
wires from meter
Bare neutral/ground
wire from meter
Main breaker
Keep branch-circuit wiring
outside of gutter posts.
Wires cannot cross over
breakers from one side
to another.
Neutral/grounding
busbar
Double-pole breaker
controls subpanel
Hot buses, or legs
Branch circuits
Neutral/grounding bus bar
Bonding connector on either
neutral/ground buses
Gutter posts
Knock-outs
located on top,
bottom, and
side of panel
Removable bar joins neutral
and grounding buses
4-wire (SER) cable
to subpanel
Ground wire connects
to grounding electrode


PELIGRO
DANGER
SIEMENS
SERVICE DISCONNECT
Handyman



Safety Switch - Disconnect Switch
Fusible or Non-Fusible
250V or 600V
2 Pole or 3 Pole
30A
60A
100A
200A
400A
600A
800A
1200A

4 & 6-Pole Heavy Duty Safety Switches
Two-speed, two-winding motors
4-pole switches are also used in 3-phase, 4-wire circuits when a switching neutral is required.

Electrical Drawings

The drawings (plans) that are most important for understanding the scope of work for the project's electrical distribution system are:

- ☐ Single-Line Diagram (One-Line Diagram, Electrical Riser Diagram)
- ☐ Panel Schedules
- ☐ Equipment Schedules and HVAC Schedules
- ☐ Lighting Control

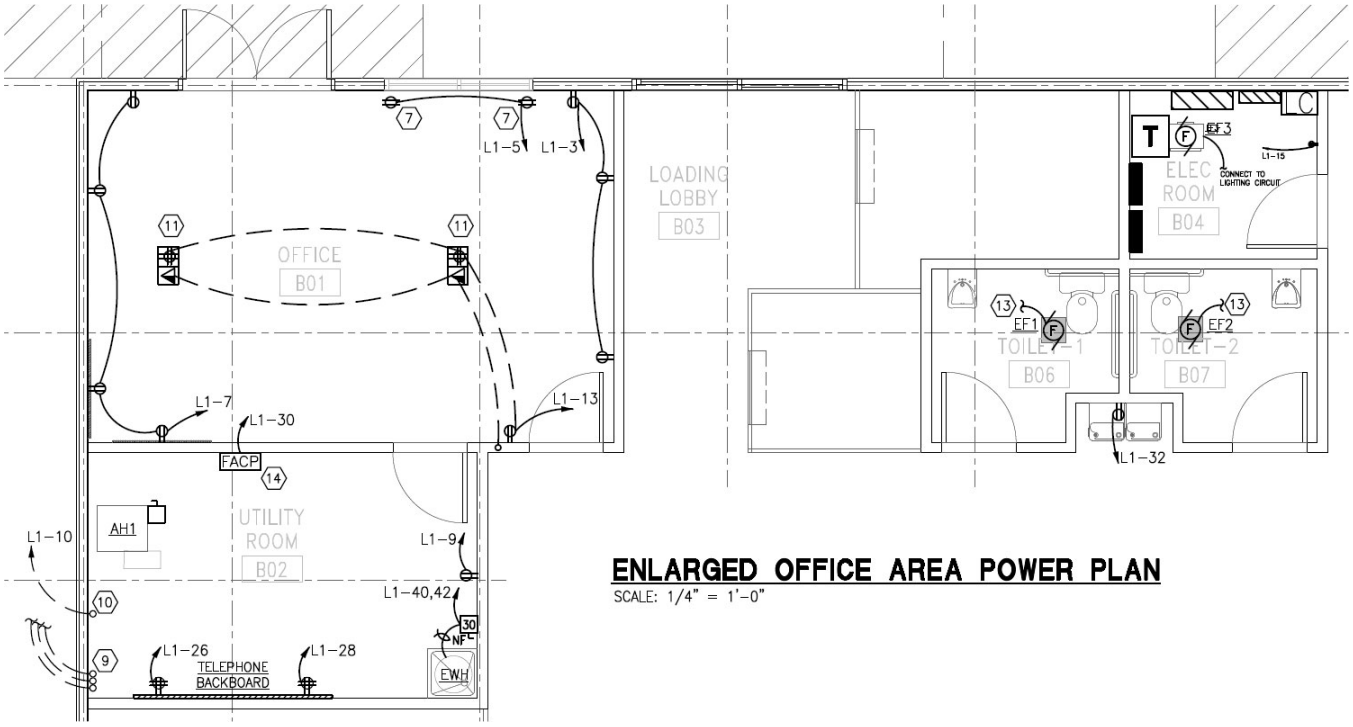
Example Project – Broward Northside, Climate Controlled Storage

Drawings

E – 02 [Electrical Room, Elevator Equipment Room]

E – 03 [Single-Line Diagram, Exterior Lighting Control]

E – 04 [Panel Schedules, HVAC Equipment Schedules]



Drawing E-1 Lower Level Electrical Plan

Electrical Legend (Partial)

Drawing E - 01

480 VOLT PANELBOARD

208/120 VOLT LIGHTING AND APPLIANCE TYPE PANELBOARD

MOTOR

FUSIBLE DISCONNECT SWITCH; NF IS NONFUSED