

Electrical Distribution Systems

By

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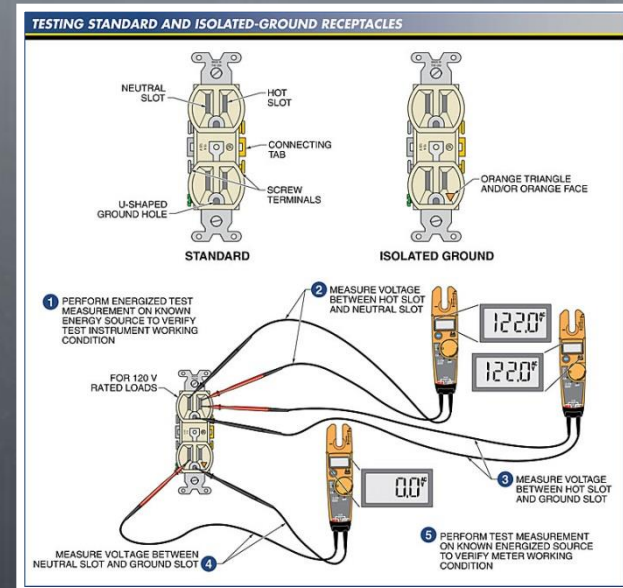
The type, location, and usage of receptacles are identified by a schematic symbol on a schematic drawing or electrical print.

RECEPTACLES

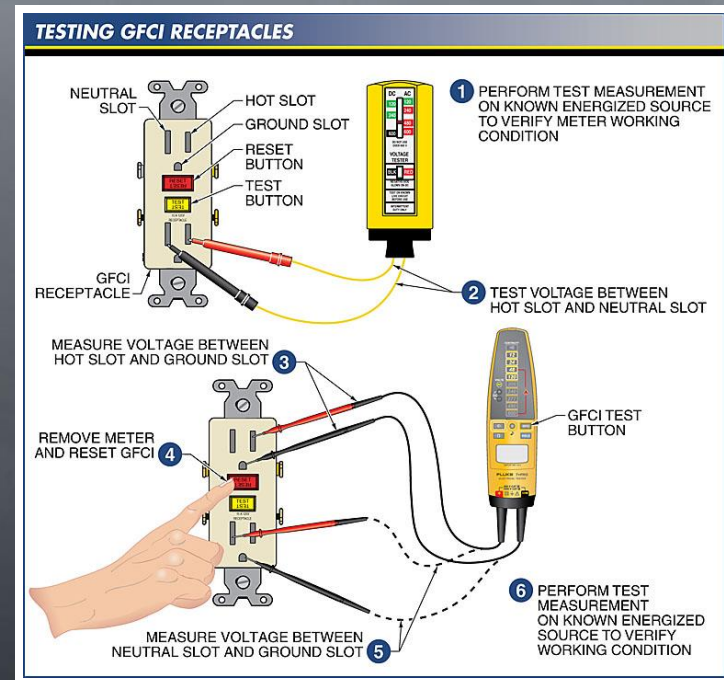
RECEPTACLE TYPES AND SYMBOLS

| Device | Type | Symbol | Device | Type | Symbol |
|--------------------|-----------------|--------|-------------------------------|---|--------|
| Single outlet | Abbr = OUT. | | Single special-purpose outlet | Abbr = SS OUT. | |
| Duplex | Abbr = DX RCPT | | Duplex special-purpose | Abbr = DS RCPT | |
| Duplex floor | Abbr = DF RCPT | | Floor special-purpose outlet | Abbr = FSP OUT. | |
| Isolated ground | Abbr = IG | | GFCI | Abbr = GFCI | |
| Split-wired duplex | Abbr = SPW RCPT | | Special-purpose connection | Abbr = OUT. DW (dishwasher) OUT. CD (clothes dryer) | |

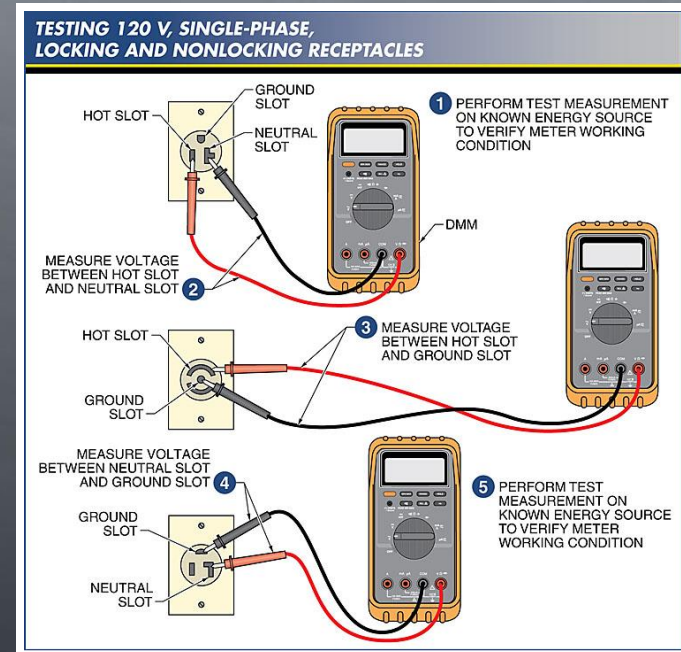
Standard and isolated-ground receptacles can be tested for proper wiring connections using a DMM or voltage tester.



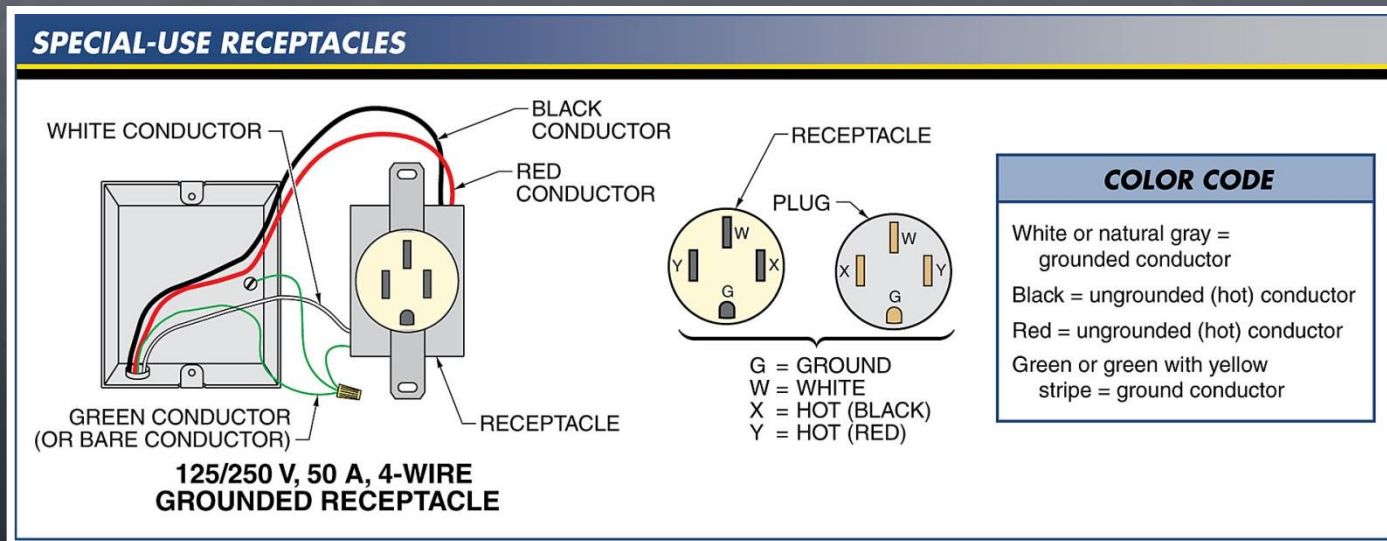
GFCI receptacles are tested to verify that the hot, neutral, and ground slots are properly wired and to verify that the electronic fault detection and trip circuit is functioning properly.



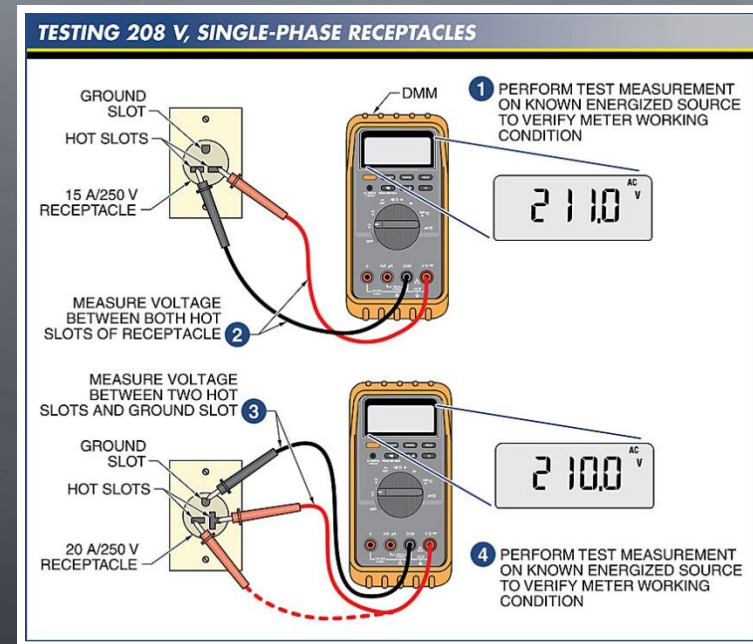
When testing a 120 V, single-phase receptacle, the receptacle is tested to verify that the voltage level is within an acceptable range for the equipment and circuit and that the receptacle is wired properly.



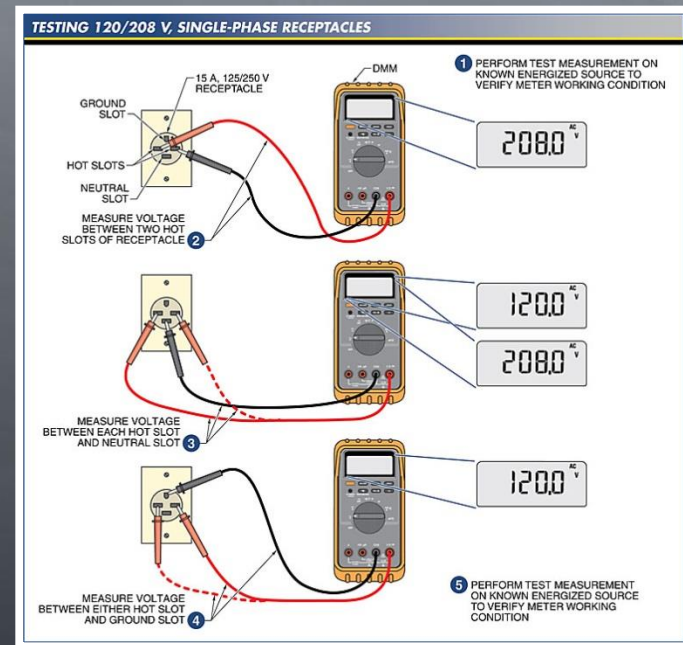
Single-phase high-power loads are designed to operate on 208 V, while some loads can operate on either 208 V or 120 V.



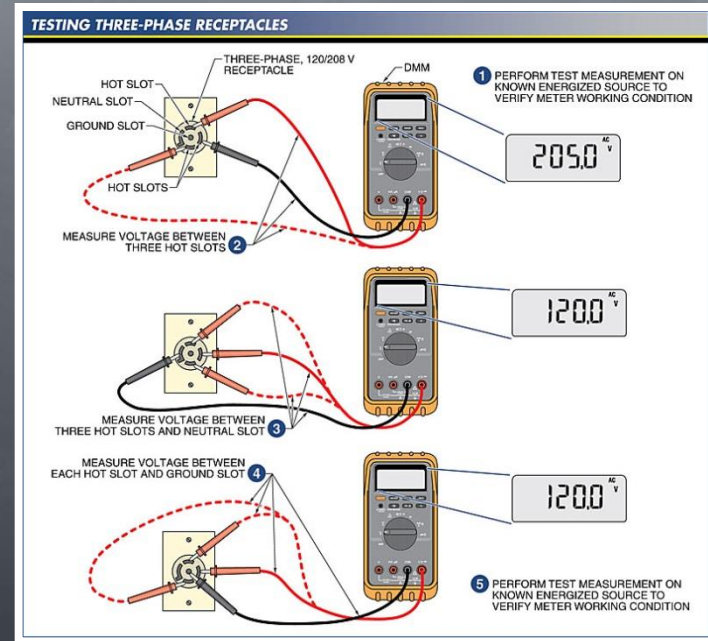
A 208 V, single-phase receptacle is tested to ensure that the voltage level is within an acceptable range for the equipment and circuit and that the receptacle is properly grounded.



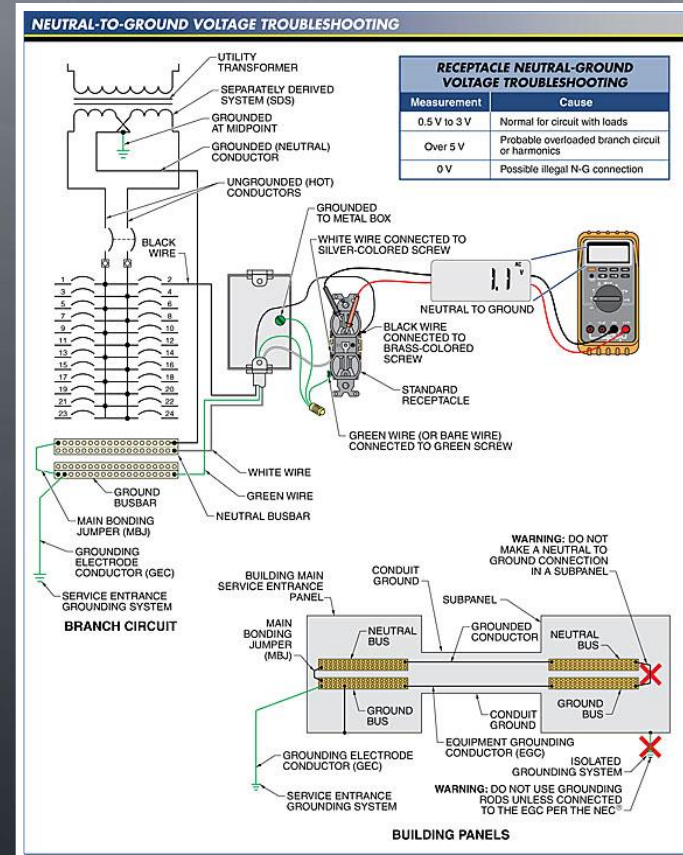
When testing a 120/208 V, single-phase receptacle, the receptacle is tested to verify that both voltage levels are within an acceptable range for the equipment and circuit and that the receptacle is wired properly.



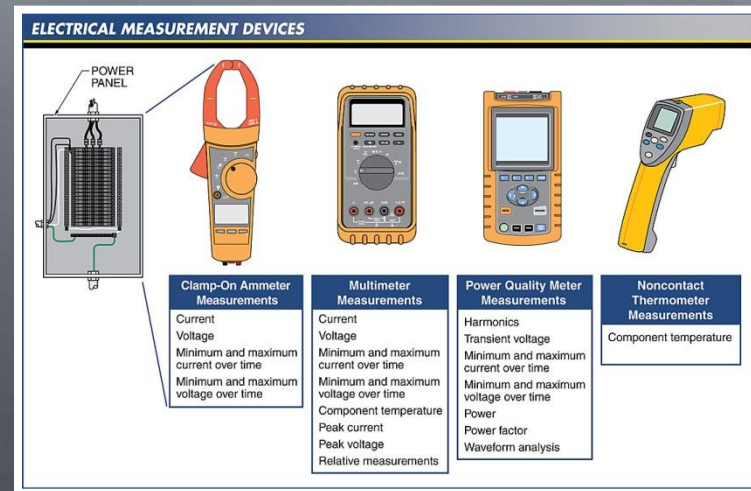
Three-phase receptacles require that the voltage between every slot on the receptacle be tested because they can be powered by different voltages.



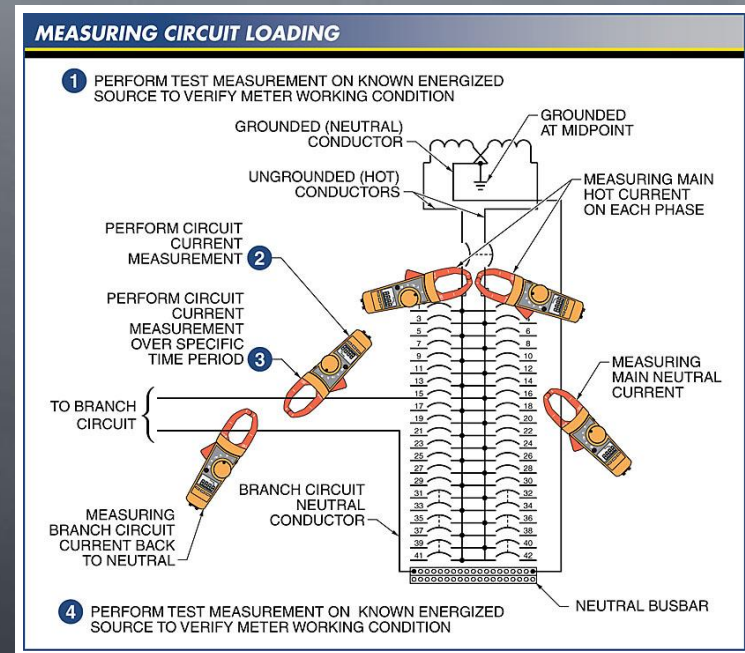
Measuring the voltage between the neutral and ground can help determine if there are any illegal neutral-to-ground connections.



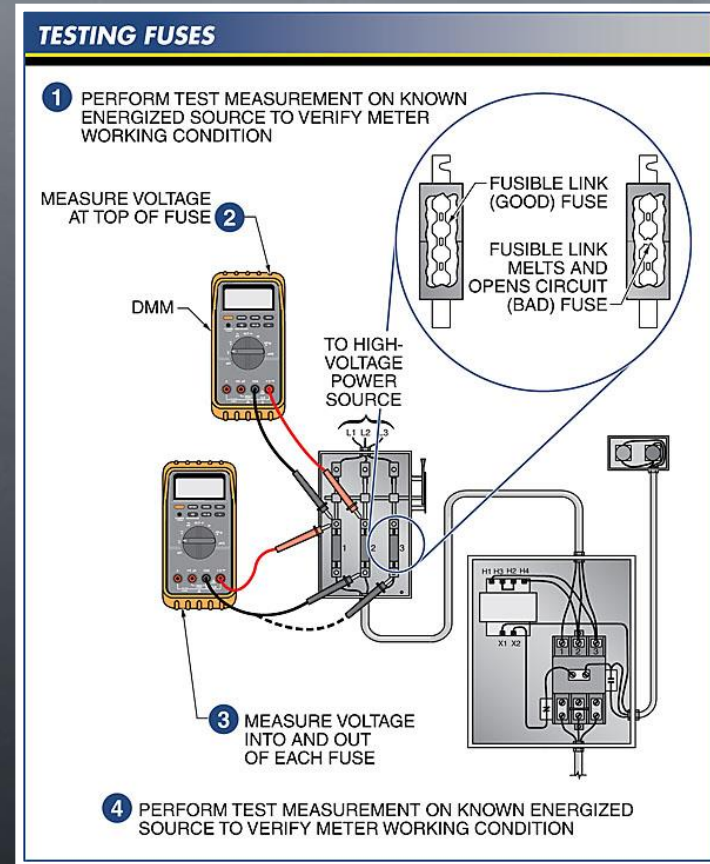
In addition to clamp-on ammeters and DMMs, electrical measurements can be taken at a power panel with power quality meters and noncontact thermometers.



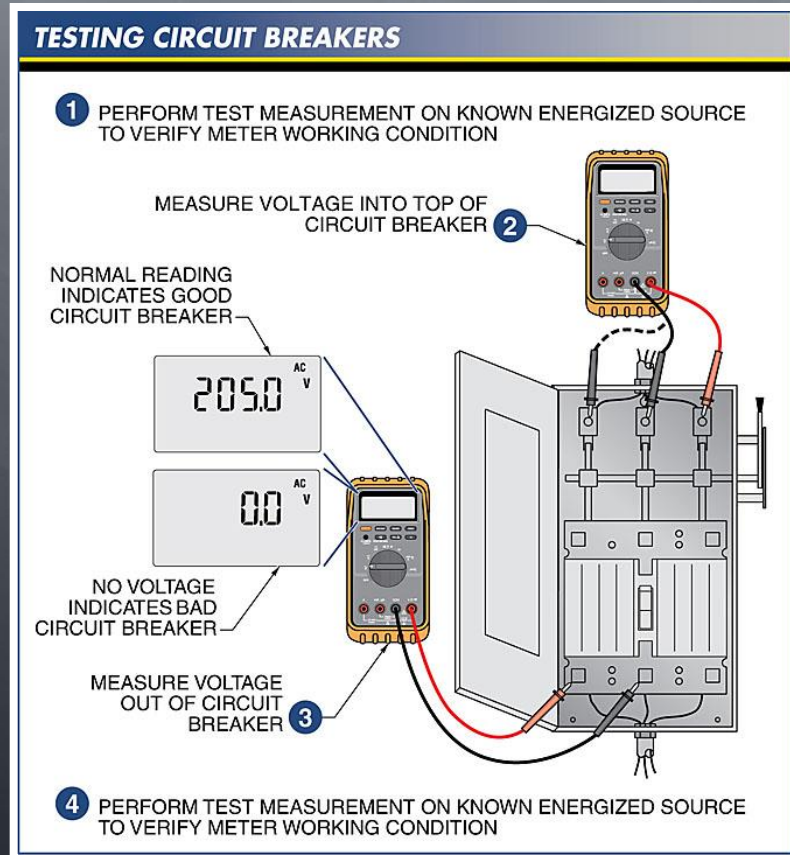
Measuring the current at fuses and circuit breakers indicates the amount of load on a circuit (current draw).



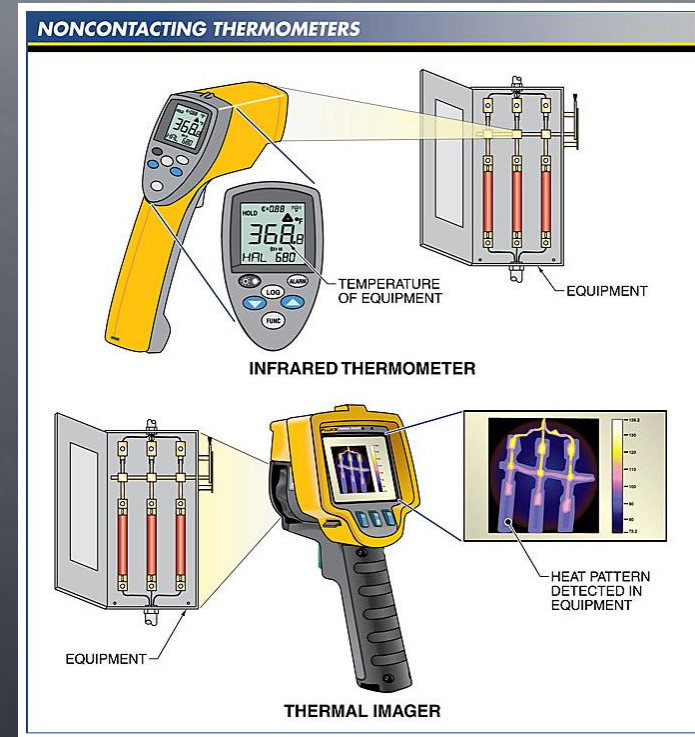
Fuses are tested with an ohmmeter or DMM with a continuity function.



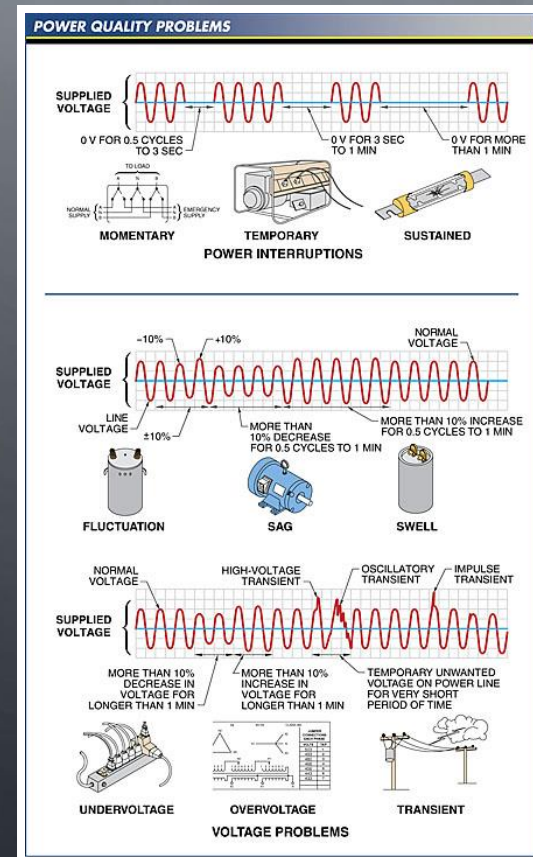
Circuit breakers that are suspected of having a problem can be tested using a DMM or voltage tester.



Infrared (IR) thermometers and thermal imagers can be used to identify problems in building power distribution systems without making physical contact with the equipment to be tested.



Power quality problems can damage electrical equipment and lead to unsafe operating conditions.



At no time should an electrical circuit have more than a 3% voltage drop from the start of the circuit (panel) to the farthest point.

TESTING VOLTAGE DROP

- PERFORM TEST MEASUREMENT ON KNOWN ENERGIZED SOURCE TO VERIFY METER WORKING CONDITION

MEASURE VOLTAGE AT START OF CIRCUIT (IN CIRCUIT BREAKER PANEL) IN NO-LOAD CONDITION

120.0 AC V

375 FT

SYSTEM GROUND

MEASURE VOLTAGE AT FARTHEST POINT IN CIRCUIT IN NO-LOAD CONDITION

119.5 AC V
NO LOAD VOLTAGE

MEASURE VOLTAGE AT FARTHEST POINT IN CIRCUIT IN FULL-LOAD CONDITION

112.8 AC V
FULL-LOAD VOLTAGE

HID LAMP

- DIVIDE VOLTAGE READING FROM MEASUREMENT TAKEN WITH ALL LOADS ON BY VOLTAGE READING FROM MEASUREMENT TAKEN WITH NO LOADS ON TO FIND PERCENTAGE VOLTAGE DROP BETWEEN NO LOAD AND FULL LOAD CONDITIONS

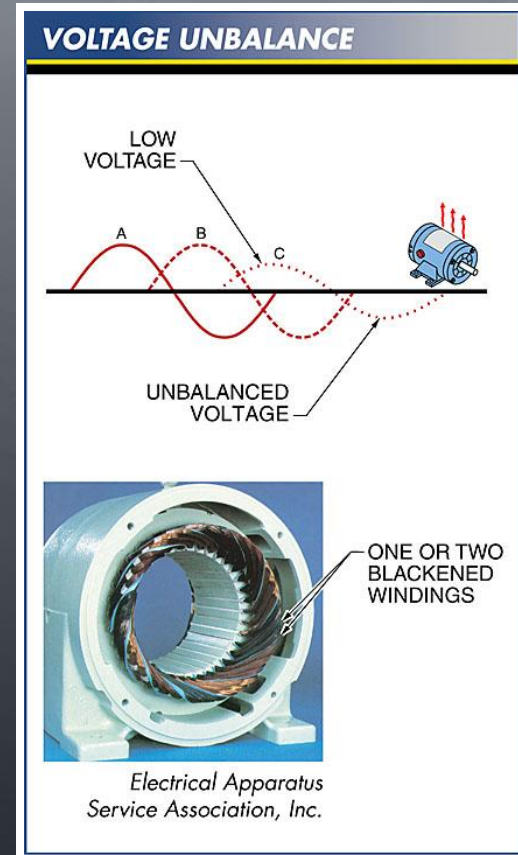
$$\frac{112.8}{119.5} = 0.94 \quad 100\% - 94\% = 6\%$$

- DIVIDE VOLTAGE READING FROM MEASUREMENT TAKEN WITH ALL LOADS ON (FULL LOAD) BY VOLTAGE READING FROM MEASUREMENT TAKEN AT START OF CIRCUIT TO FIND PERCENTAGE VOLTAGE DROP ACROSS ENTIRE CIRCUIT

$$\frac{112.8}{120} = 0.94 \quad 100\% - 94\% = 6\%$$

- IF EITHER ANSWER IN STEP 5 OR 6 IS GREATER THAN 3%, CHECK CIRCUIT FOR IMPROPER CONDUCTOR SIZE, TOO LONG OF CIRCUIT RUN, AND/OR TOO MANY LOADS ON CIRCUIT (EVEN IF CIRCUIT BREAKER DOES NOT TRIP).
- PERFORM TEST MEASUREMENT ON KNOWN ENERGIZED SOURCE TO VERIFY METER WORKING CONDITION

Voltage unbalance within a power distribution system can cause high current unbalance in loads such as electric motors.



In general, voltage unbalance should not be more than 1%. Whenever there is a 2% or greater voltage unbalance, corrective action should be taken.

DETERMINING VOLTAGE UNBALANCE

- PERFORM TEST MEASUREMENT ON KNOWN ENERGIZED SOURCE TO VERIFY METER WORKING CONDITION
- MEASURE INCOMING VOLTAGE
- ADD VOLTAGES

| |
|--------|
| 442 |
| 474 |
| + 456 |
| ----- |
| 1372 V |
- FIND VOLTAGE AVERAGE

$$V_a = \frac{V}{3}$$

$$V_a = \frac{1372}{3}$$

$$V_a = 457 \text{ V}$$
- FIND LARGEST VOLTAGE DEVIATION

$$V_d = V - V_a$$

$$V_d = 474 - 457$$

$$V_d = 17 \text{ V}$$
- FIND VOLTAGE UNBALANCE

$$V_u = \frac{V_d}{V_a} \times 100$$

$$V_u = \frac{17}{457} \times 100$$

$$V_u = 0.0372 \times 100$$

$$V_u = 3.72\%$$
- PERFORM TEST MEASUREMENT ON KNOWN ENERGIZED SOURCE TO VERIFY METER WORKING CONDITION

MEASURE INCOMING VOLTAGE 2

DISCONNECT OFF

L1 L2 L3

L1 TO L2: 442_{AC}

L1 TO L3: 474_{AC}

L2 TO L3: 456_{AC}

Current unbalance is determined in the same manner as voltage unbalance, except that current measurements are used.

DETERMINING CURRENT UNBALANCE

- PERFORM TEST MEASUREMENT ON KNOWN ENERGIZED SOURCE TO VERIFY METER WORKING CONDITION

ASI Robicon
POWER QUALITY CABINET CONTAINING TRANSFORMERS, REACTORS, POWER FACTOR CORRECTION CAPACITORS, AND FILTERS

DISCONNECT
Siemens
L1/R
L2/S
L3/T
MEASURE INCOMING CURRENT ON EACH POWER LINE

- ADD CURRENT VALUES

| |
|--------------|
| 58 |
| 53 |
| + 57 |
| 168 A |
- FIND CURRENT AVERAGE

$$C_a = \frac{C}{3}$$

$$C_a = \frac{168}{3}$$

$$C_a = 56 \text{ A}$$
- FIND LARGEST CURRENT DEVIATION

$$C_d = C_c - C$$

$$C_d = 56 - 53$$

$$C_d = 3 \text{ A}$$
- FIND CURRENT UNBALANCE

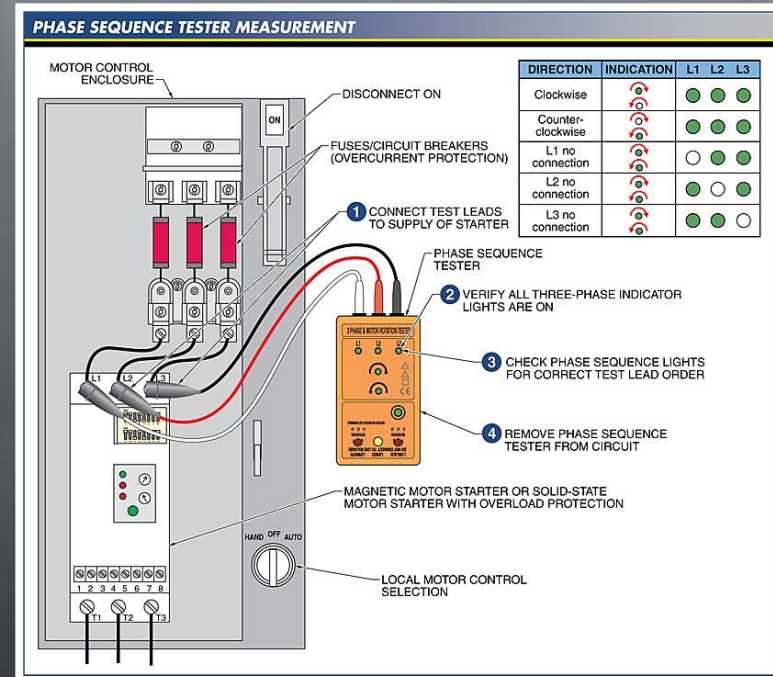
$$C_u = \frac{C_d}{C_a} \times 100$$

$$C_u = \frac{3}{56} \times 100$$

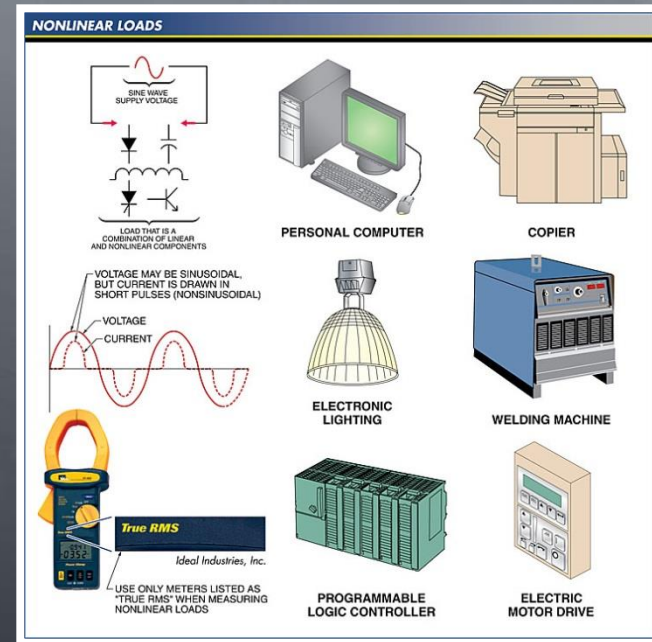
$$C_u = 0.0535 \times 100$$

$$C_u = 5.35\%$$
- PERFORM TEST MEASUREMENT ON KNOWN ENERGIZED SOURCE TO VERIFY METER WORKING CONDITION

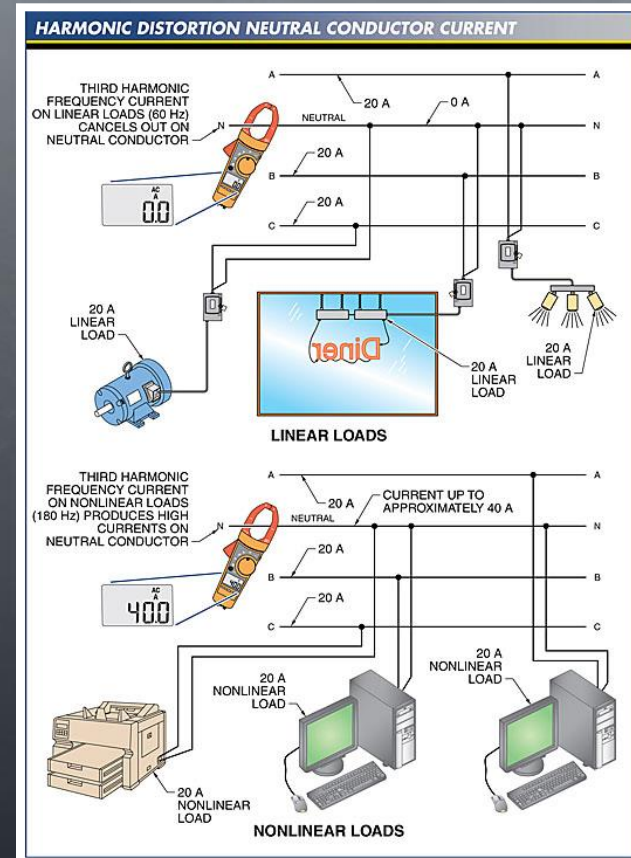
The phase sequence of power lines can be verified using a phase sequence tester.



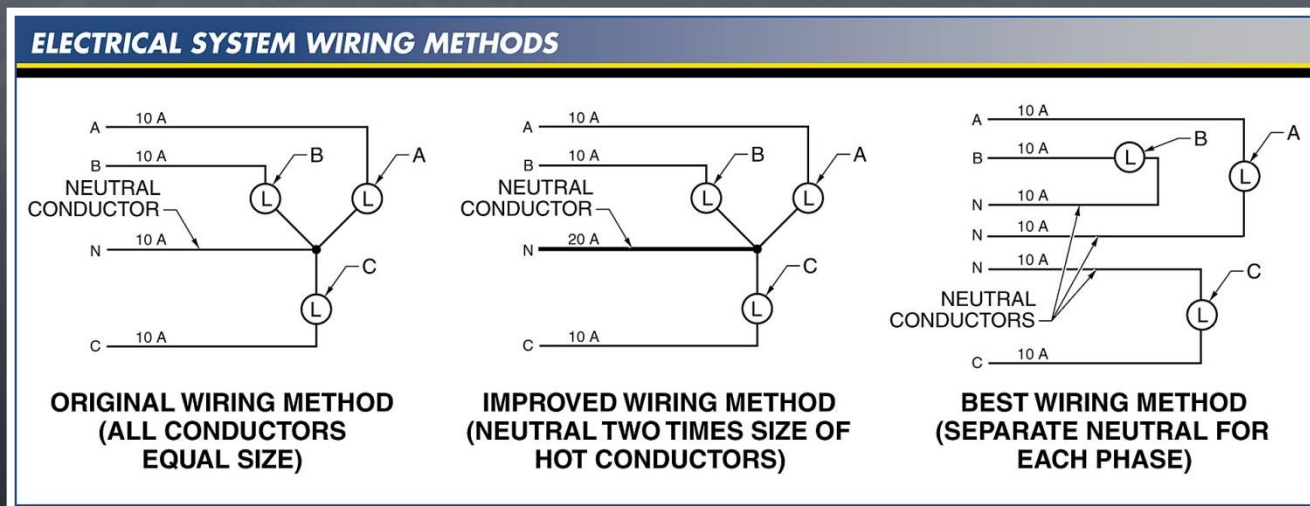
In nonlinear loads, current is not a pure proportional sine wave because current is drawn in short pulses.



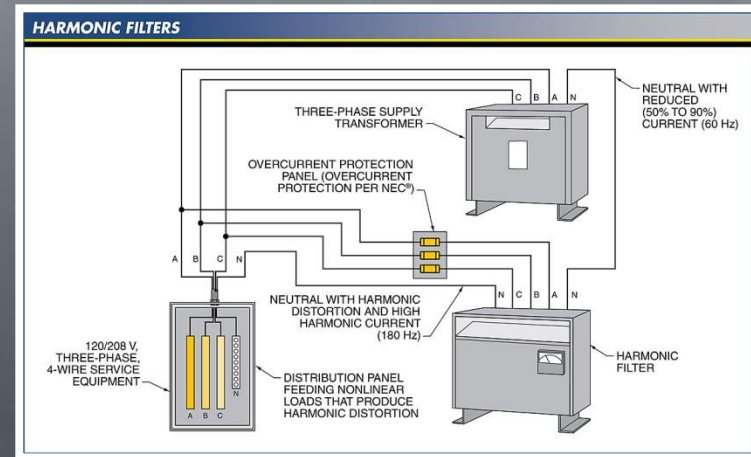
The third harmonic current frequency (180 Hz) on nonlinear loads produces high currents on the neutral conductor.



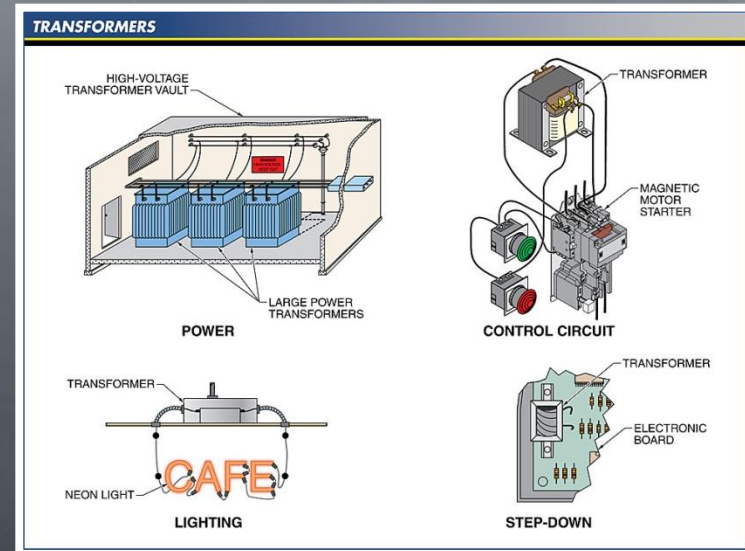
To reduce harmonic distortion and overheating problems, the best wiring method is one in which each circuit has its own neutral conductor (no shared neutrals).



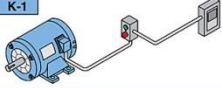

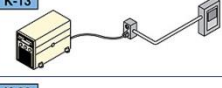
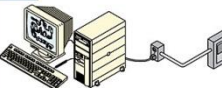
Three-phase harmonic filters are installed between the transformer and distribution panel to reduce harmonic frequencies and total harmonic distortion.

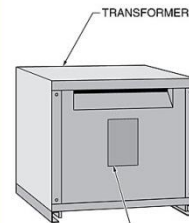


Common types of transformers used in commercial applications include power, control circuit, lighting, and step-down transformers.



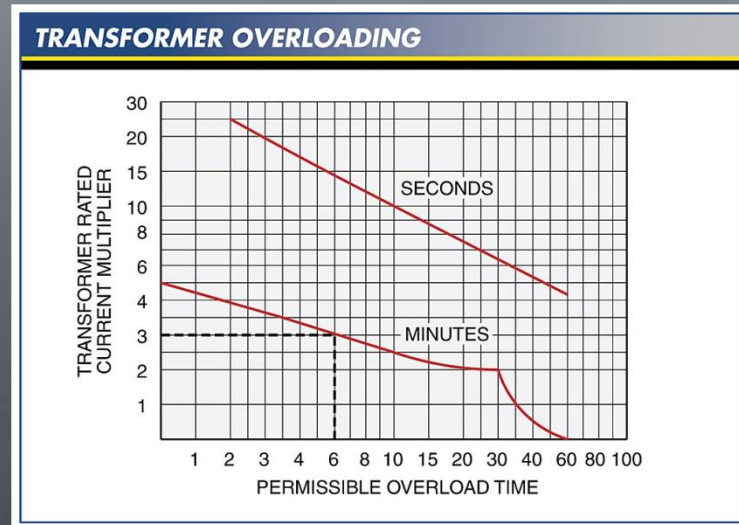
A K-rated transformer is a transformer designed to handle the extra heating effects caused by harmonic distortion.

| K-RATED TRANSFORMERS | |
|--|--|
| K-RATED TRANSFORMER APPLICATIONS | |
| K Factor | Device |
| K-1  | <ul style="list-style-type: none"> • Motors • Incandescent lamps • Heating elements • Solenoids • Transformers |
| K-4  | <ul style="list-style-type: none"> • Welders • Induction heating units • Solid-state controls • Fluorescent lamps • HID lamps |
| K-13  | <ul style="list-style-type: none"> • Mixed linear and nonlinear loads • Uninterruptible power systems (UPS) • Telecommunication equipment |
| K-20  | <ul style="list-style-type: none"> • Desktop computers • Variable-frequency motor drives • Mainframe computers |



K RATING LISTED ON TRANSFORMER NAMEPLATE

Because transformers can be overloaded for short periods, it is important when taking measurements to take them over incremental time periods.



Control-circuit transformers are tested by checking for open circuits in the coils, short circuits between the primary and secondary coils, and coils shorted to the core.

