

**NUMERIC**

**120V AC**

The line to neutral voltage in a single-phase two wire AC, not including green safety ground, system as commonly found in the US.

**240V AC**

The line to line voltage in a single-phase three wire (not including green safety ground) AC system as commonly found in the US.

**230V AC**

The line to neutral voltage in a single-phase two wire (not including green safety ground) AC system as commonly found in Europe and many other parts of the world.

**3 phase** *see also Single Phase*

Refers to 3 phase power generation typically 480V AC and higher. The AC utility is a three-phase system. In its simplest form there are three conductors connected to three conductive coils, which pass through a magnetic field, thus, inducing the electrons in the wires to flow. As the polarity of the magnetic field changes from North to South, electrons are induced to flow first one way then the other. This produces AC current flow. The current that is induced in the three wires is 120° out of phase. The current flow in the first conductor starts 120° before the second and it starts 120° before the third. Three phase generators are only found on the largest boats.

**3 stage charging**

A technique of battery charging that uses three distinct stages to ensure a fast and complete charge and a safe maintenance voltage. As there are several manufacturers of multiple stage charging systems, there is a slight difference in terminology in the field. See each key word for a more complete definition.

- Stage 1: Charge or Bulk Mode
- Stage 2: Acceptance or Absorption
- Stage 3: Float

**A**

**ABYC**

American Boat and Yacht Council, a voluntary standards creating body for the marine industry responsible for Standards and Recommended Practices.

**AC**

*see Alternating Current*

**AFD**

*see Alternator Field Disconnect*

**AGC Fuse**

A 1-1/4 inch long x 1/4 inch diameter glass fuse with fast blow characteristics.

**AIC Amperes Interrupt Capacity**

*see Interrupt Rating*

**ATO/ATC Fuse**

The blade type fuse now commonly used in the automobile industry. It has fast blow characteristics like the AGC fuse.

**AWG (American Wire Gauge)**

*see also SAE Wire Gauge*

AWG (American Wire Gauge) is a U.S. standard set of non-ferrous (copper or aluminum) wire conductor sizes. The "gauge" refers to the diameter. Typical household wiring is AWG number 12 or 14. Telephone wire is usually 22, 24, or 26. The higher the gauge number, the smaller the diameter and the thinner the wire. Thicker wire can carry more current because it has less electrical resistance over a given length. Also larger wire is used when the voltage drop along its length must be minimized. For example: High output alternator wiring might be a 2 AWG while the starter cable for a modest engine a 1 or 0 AWG.

**absorption** *see 3 Stage Charging*

*see also Float Charge, Bulk, Equalization*

Absorption refers to the second phase of a multistage charging system, also called acceptance by some manufacturers. During the absorption cycle the battery is maintained at the maximum charging voltage. Typically about 2.4V per cell or 14.4V for a typical 12V system. (28.8V for a 24V system). This is the gassing voltage for a liquid battery. Gelled batteries are typically charged at slightly lower voltages. The gassing voltage is also temperature dependent. The battery cannot be maintained for long periods of time in the absorption phase.

**acceptance**

*see absorption*

**alternating current**

A periodic current (sine wave) with an average value over a cycle of zero. The current reverses at regular intervals of time and has alternately positive and negative values.

**alternator**

Commonly refers to the DC charging source on an engine. The alternator is a three-phase AC device that produces alternating current, which is then rectified by a diode bridge to create direct current. Three-phase AC devices are reliable and inexpensive to make compared to a DC generator of the same ampacity.

**alternator field disconnect**

The alternator field is created by a coil of wire surrounded by ferrous metals. When the coil is energized with electric current it becomes an electro-magnet. This electromagnet is rotated, inducing current flow in the three phase coils that surround it. By controlling the strength of the magnetic field, the output of the alternator may be controlled. If the output of the alternator is open circuited there is no place for the energy to go. The voltage rises to a dangerous level. By disconnecting the alternator field, the magnetic field is turned off, thus the voltage cannot soar. This is a safety feature on some battery switches.

**ambient temperature**

The temperature of the medium in which the heat of a device is dissipated. The ambient temperature is often specified in standards for device performance (such as the UL Standards) as the basis for determining the heat rise of the component.

**ammeter**

Ammeter measures current flow in a circuit. An ammeter is inserted in series in the circuit. We consider four types:

*Analog*

The classic analog ammeter uses the magnetic field associated with current flow through a moving coil of wire, to in turn move a needle over a meter face which displays amps. This type of meter can only measure very small current, micro-amps, before the moving coil becomes too large to be practical. To measure higher currents a shunt resistor is inserted into the circuit. (see Shunt). Most of the current flows through the shunt resistor but some passes through a meter movement as described to read amps when the movement is scaled appropriately.

*Digital DC*

The digital DC ammeter uses a shunt resistor to measure current flow. (see Shunt). The shunt is connected in series in the wiring of the circuit whose current is to be measured. The shunt sense leads are connected to the DC ammeter, which is really a millivolt meter. The millivolt input from the shunt is scaled to read amps per the resistance of the shunt. For example, a current flow of 10 amps through a 100A:100mV shunt would result in a voltage of 10mV across the sense leads. A millivolt meter would display 10, which we would interpret as 10 Amps.

*Digital AC*

The digital AC ammeter also uses a shunt resistor to measure a voltage drop, which is then scaled to read amps. The difference, however, is that the resistor is not normally connected directly in the AC wire of the circuit to be measured. A device called a current transformer (CT, see Current Transformer) is placed around the AC wire. A current is induced in the CT, which is then passed through a load resistor. The digital meter actually measures the voltage across this load resistor and internally scales it to read the appropriate number of amps.

*Portable*

Most portable meters today are digital and use the same techniques of measurement as described above. However, they are commonly limited to a few amps when connected in series to measure current. If high currents are to be measured, the portable meter must use some external sensing means. Commonly these consist of shunt resistors and clamp-on ammeter sensors that use Hall Effect sensors. (Operation of which are beyond the scope of this appendix. In short, they generate a voltage, which can be scaled to read amps just as the shunt resistor.)

**ampacity**

The current carrying capacity of a conductor or device.

**ampere** *see Coulomb*

*Definition 1*

The classic definition of an ampere is a unit of electric current flow equivalent to the motion of 1 coulomb of charge, or 6.25 X 10<sup>18</sup> electrons, past any cross section in 1 second. This is an intuitive way to think about an ampere. It is the flow of a huge number of electrons through a conductor.

*Definition 2*

In 1948 this alternative definition was adopted: A unit of electric current in the meter-kilogram-second system. It is the steady current that when flowing in straight parallel wires of infinite length and negligible cross section, separated by a distance of one meter in free space, produces a force between the wires of 2 x 10<sup>-7</sup> newtons per meter of length.

**ampere-hour**

The electric charge transferred past a specified circuit point by a current of one ampere in one hour.

**Amp-Hour Rating (AH)**

This is a common rating for batteries. This is the total number of ampere-hours that a battery can deliver over 20 hours at a constant rate of discharge before the battery voltage falls below 10.5 volts.

**analog**

Refers to a signal or input that varies continuously over time. Voltages and currents are analog signals, as are temperature and pressure.

**anode**

The electrode of an electrochemical cell with the more negative potential. The less noble metal of an electrolytic cell that tends to corrode.

**B**

**battery** *see also Cell*

Two or more cells connected together. Thus a group of batteries connected together can also be referred to as a battery.

**battery bank**

When groups of batteries are wired in series or parallel or a combination to increase voltage or capacity the entire group is referred to as a battery bank. When batteries are connected in series the amp-hour rating is the same and the voltage is additive. When batteries are connected in parallel the voltage is the same and the amp-hour rating is additive.

**battery state-of-charge**

The term is used to describe and estimate of how much energy the battery is able to deliver. There have been many attempts to develop improved state-of-charge estimates. The most common methods include: specific gravity, at-rest open-circuit voltage, and amp-hour measurement.

**battery switch rating**

see *Continuous Switch Rating and Intermittent Switch Rating*

**battery types**

*AGM (Absorbed Glass Mat)*

A technique for sealed lead-acid batteries. The electrolyte is absorbed in a matrix of glass fibers, which holds the electrolyte next to the plate, and immobilizes it, preventing spills. AGM batteries tend to have good power characteristics, low internal resistance, and good behavior during charging.

*Flooded*

A design for lead-acid batteries. The electrolyte is an ordinary liquid solution of sulfuric acid. Flooded cells are prone to making gas while being charged. Flooded cells must be periodically checked for fluid level and water added as necessary. Flooded cells are also typically less expensive than AGM or gel cell type lead-acid batteries.

*Gel cell*

Gel or sealed lead acid batteries are basically the same chemistry as a wet (flooded cell) battery. The batteries' electrolyte is in a gelatin form and is absorbed into the plates and the battery is sealed with epoxies. The batteries are exceptionally leak resistant and may be used in any position. Battery uses include UPS, emergency lights, and camcorders. These batteries are 2 volts per cell, so the common batteries are 4, 6, and 12 volt.

**blade**

That portion of a fuse to which the fuse block connects.

**bonding, cathodic**

The electrical interconnection of metal objects in common contact with water, to the engine negative terminal, or its bus, and to the source of cathodic protection.

**branch circuit** see also *Main*

The portion of the wiring system after the main circuit protection device.

**break (rating)**

The amount of current that can be passing through a set of contacts, such as those in a solenoid, when they open, without damaging the contacts. This can be a rating for a single event or over some number of cycles, generally 1000, 10,000 or 1,000,000.

**bulk**

That part of a multi-stage charge regime at which the maximum amount of current is flowing. This is normally limited by the size of the charging source. Lead acid batteries have the ability to accept, or absorb, large charging currents as long as they do not overheat or begin gassing. The bulk cycle allows the fastest possible charge.

**bus, busbar**

A bus is a group of common connections, often consisting of a strip of copper or brass with a number of screws or bolt studs for the connection of wires. It may be a negative or a positive bus.

C

**CE (Conformité Européenné)**

The CE marking is a conformity marking consisting of the letters "CE". The CE marking is applied to products regulated by certain European health, safety and environmental protection legislation. The CE marking is obligatory for products it applies to. The manufacturer affixes the marking certifying that the product conforms to applicable regulations, in order to be allowed to sell the product in the European market.

**CFR (Code of Federal Regulations)**

The written regulations of the United States Federal Government.

**cathode**

The electrode of an electrochemical cell with the more positive potential. The more noble metal of an electrolytic cell that tends not to corrode.

**cell**

An electrochemical system that converts chemical energy into electrical energy. Typically consisting of two conductive plates with different galvanic potential immersed in an electrolyte.

**cell, primary**

An electrochemical device, which is discharged only once and then, discarded.

**cell, secondary**

see also *Battery*  
An electrochemical device, which may be discharged and recharged a number of times.

**charge**

Classically refers to an accumulation of electrons producing an electrostatic charge. In common use it often refers to restoring energy to a battery. Specifically, it would refer to the part of a multi-stage battery charging cycle when the voltage was held constant at or about the gassing voltage.

**charge cycle**

The stages through which a multi-stage charging source restores energy to a battery. A four-stage charge cycle includes:

*bulk or charge cycle*

Constant current for fast charging

*acceptance or absorption cycle*

Constant voltage for thorough charging

*float cycle*

For maintenance and long life

*equalization cycle*

Controlled overcharge for maximum capacity. see *key words above*

**circuit**

A closed path of electrically, or electro-magnetically connected, components or devices that is capable of current flow. Typically consisting of loads, sources, conductors, and circuit protection (circuit breakers and fuses). For example: A battery, fuse, and bilge pump connected together with wire are a circuit. The path must be continuous and closed.

**circuit breaker**

A device that, like a fuse, interrupts current in an electric circuit when the current becomes too high. Unlike a fuse, a circuit breaker can be reset after it has tripped. When high current passes through the circuit breaker, the heat it generates or the magnetic field it creates causes a trigger to rapidly separate the pair of contacts that normally conduct the current.

**Circular mils**

A method of specifying wire size mathematically. One Circular Mil is a unit of area equal to that of a circle .001" in diameter. The actual area of a Circular Mil is:

$$A = \pi r^2$$

$$A = 3.1428 \times (.0005)^2 \text{ inches}$$

$$A = .0000007857 \text{ square inches}$$

**Class-T fuse**

A very robust fuse with a 20,000 AIC. It also has very fast response to short circuit currents.

**coil**

see *inductor*

**Cold Cranking Amperes (CCA)**

see also *Marine Cranking Amperes*

CCA is the discharge load in amps which a battery can sustain for 30 seconds at 0° F. (-18° C) and not fall below 1.2 volts per cell (7.2V on 12V battery). This battery rating measures a burst of energy that an engine needs to start in a cold environment. This

rating is used mainly for rating batteries for engine starting capacity and does not apply to NiCad batteries, NiMH batteries or Alkaline batteries.

**common**

May have more than one meaning. Typically denotes a bus that is at ground potential most often. The negative bus is called "the common"; sometimes the neutral bus is also called "the common". May also mean a group of connections that are connected together "in common" even though they are at a different potential than ground.

**conductivity**

Conductance is the reciprocal of resistance, which depends on the resistivity constant of the material. Resistivity is the resistance of a conductor having unit cross section and unit length. Conductivity is the reciprocal of the resistivity. Its units are 1/ohm-cm or ohm/cm, or 1/ohm-circular mils/ft.

**conductor**

That part of an electrical circuit whose resistance relative to the balance of the circuit is zero. For example, in a circuit consisting of a light bulb and a battery, connected together with wire, the wire is referred to as the conductor.

**Conformité Européenné**

see *CE*

**continuous current**

The current flow, which a device or a conductor can carry, consume, or supply with no time limit. The continuous current rating is normally dependent on the temperature, since resistance increases with temperature. For battery switches the continuous current rating is established by testing for one hour at the rating. This is reasonable since thermal equilibrium would be reached within one hour.

**continuous switch rating (UL 1107)**

The two ratings in the UL marine battery switch standard are Intermittent and Continuous. Intermittent is a 5 minute rating and is based on temperature rise of various sections of the switch as the rated current is applied over a 5 minute period. The Continuous rating is the same, but the time period is 1 hour.

**converter**

An electrical device that converts one type of electrical energy into another. Battery chargers convert AC power to DC to charge the battery. Inverters convert DC power into AC, both are converters. Often used in RV industry to mean a power supply that runs the domestic DC loads when shore power is available.

**coulomb** see also *Ampere*

The measurement unit of electric charge, which is determined by the number of electrons in excess (or less than) the number of protons. Classically a charge of 1 coulomb = 6.25 X 10<sup>18</sup> electrons. The meter-kilogram-second unit of electrical charge equal to the quantity of charge transferred in one second by a steady current of one ampere.

**counterpoise**

That portion of an antenna system composed of wires or other types of conductor arranged in a circular pattern at the base of the antenna at a certain distance above ground. Insulated from the ground, it forms the lower system of antenna conductors.

**cranking (starting)**

Normally associated with "cranking current" which is the current required by the starter circuit prior to engine starting. The cranking current varies significantly during the starting cycle. Initially, there is a large surge of current required to overcome the inertia and compression of the engine. This surge can be two to four times the average cranking current. Once the engine is turning there are peaks and valleys as the pistons go through the compression and exhaust cycles. The cranking current rating is used for sizing batteries, cables, and battery switches.

**current** *see also Amperage*

Current is a flow of electrical charge carriers, usually electrons or electron-deficient atoms. The common symbol for current is the uppercase letter I. The standard unit is the ampere, symbolized by A. Physicists consider current to flow from relatively positive points to relatively negative points; this is called conventional current or Franklin current. Electrons, the most common charge carriers, are negatively charged. They flow from relatively negative points to relatively positive points.

Electric current can be either direct or alternating. Direct current (DC) flows in the same direction at all points in time, although the instantaneous magnitude of the current might vary. In an alternating current (AC), the flow of charge carriers reverses direction periodically. The number of complete AC cycles per second is the frequency, which is measured in Hertz. An example of pure DC is the current produced by an electrochemical cell. The output of a power-supply rectifier, prior to filtering, is an example of pulsating DC. The output of common utility outlets is AC.

**current rating**

The maximum current in amperes that a device will carry continuously under defined conditions without exceeding specified performance limits.

**current transformer** *see also Ammeter*

The "CT", as current transformers are commonly referred to, is used by AC ammeters to "sense" current flow in a wire in an AC circuit. It is a toroidal coil of wire through which a wire whose current we wish to measure is passed. It is normally encapsulated and looks like a "doughnut", which is how electricians commonly refer to it. The doughnut has two wires coming out of it, which are connected to the AC ammeter. As current flows in the AC wire we wish to measure, it induces a current flow in the current transformer. The magnitude of the current varies directly with the current flowing in the AC wire. Current transformers are rated by the number of maximum amps that can flow in the measured wire and the current generated, by the CT, at that current flow. For example: A 50:5 CT is rated for 50 amps flowing in the measured wire, and it generates 5 amps of current as a consequence.

**cycle**

A cycle of a battery is a discharge plus a charge. For example, if a fully charged battery has a load applied, is then discharged and recharged, that is one cycle. Cycle life is the total number of cycles a battery yields.

**D**

**DC** *see Direct Current*

**deep-cycle batteries**

Batteries with thick plates to allow for reserve energy to be stored within the battery plate and released during slow discharge for prolonged periods. The high-density active material remains within the batteries' plate/grid structure longer, resisting the normal degradation found in cycling conditions. Deep cycle batteries are typically used where the battery is discharged to a great extent and then recharged.

**delay**

A difference in time between the initiation of an event and its occurrence, or between an event's observation and enunciation of it. This is usually used to refer to the time between the application of current through to a fuse or circuit breaker and the time when the device opens.

**derating**

A decrease in a device's rating, usually amperage, due to its application in ambient conditions different from those in which it was tested or for which it was designed originally.

**dielectric strength**

The maximum voltage that a material can withstand without allowing the two voltage potentials to short together.

Specifications subject to change. See [www.blueseas.com](http://www.blueseas.com) for current information.

**digital**

A digital signal is one which has only two valid values denoted as 1 or 0. Commonly these are equated to distinctly different voltage. For example: A voltage of +5V would equal a 1 and a voltage of 0V would equal a 0.

A digital meter is one that displays values as numerical values rather than as the position of a meter on a relative scale.

**Direct Current (DC)**

An electric current that always flows in the same direction. The magnitude may vary but the current direction is always the same. Commonly referred to as DC. Examples of direct current sources are batteries, fuel cells, and photovoltaic cells. DC sources such as battery chargers and alternators actually use rectified AC current as the source.

**discharge**

Refers to the consumption of energy from a battery, or to the electrostatic discharge associated with a lightning bolt, capacitor, etc.

**double insulation system**

An insulation system comprised of basic insulation and supplementary insulation, with the two insulations physically separated and arranged so they are not simultaneously subjected to the same deteriorating influences to the same degree.

**double pole**

Indicates a switch, relay, or circuit breaker with two separate conductive paths, which are opened or closed simultaneously when the device is operated.

**E**

**Earth**

The third planet from the sun in Astronomy, but in electrical terms it refers to a connection, which is made to a conductor that is connected to the planet Earth. In grounded electrical systems there is a connection, which is a copper rod or some other highly electrically conductive connection, to the actual Earth. This is to ensure a safe conductive path for a short circuit, which in turn helps prevent electrocution.

**electrode**

A conductive material, in an electrolyte, through which electrical current enters or leaves.

**electrolysis**

Chemical changes in a solution, or electrolyte, due to the passage of electric current.

**electrolyte**

A liquid in which ions are capable of migrating and, therefore capable of conducting current. Solutions of acids, bases, and salts in water are electrolytes.

**electron** *see also Coulomb*

An electron is a negatively charged subatomic particle. It can be either free (not attached to any atom), or bound to the nucleus of an atom. In electrical conductors, current flow results from the movement of free electrons from atom to atom individually, and from negative to positive electric poles in general.

The charge on a single electron is considered as the unit electrical charge. It is assigned negative polarity. Electrical charge quantity is not usually measured in terms of the charge on a single electron, because this is an extremely small charge. Instead, the standard unit of electrical charge quantity is the coulomb, symbolized by C, representing about  $6.25 \times 10^{18}$  electrons.

**Electromotive Force (EMF)**

Commonly referred to as voltage, electromotive force is the energy per unit of charge that is supplied by a source of electrical energy such as a battery, charger or alternator.

**Electromagnetic Interference (EMI)**

Noise generated by a load (typically by electrical switching action). Usually specified as meeting agency limits for conducted EMI (noise conducted back onto the power bus) or radiated EMI (noise emitted into the area surrounding a device).

**energy** *see also Power*

The classically simple definition is, the capacity to do work. Energy may be manifested as, mechanical motion, thermal heat, or electrical power, which is consumed, radiated, dissipated, or stored over a period of time. The energy in a direct-current circuit is equal to the product of the voltage in volts, the current in amperes, and the time in seconds. The units for energy are Watt-hours. In alternating current (AC) circuits, the expression for energy is more complex.

**engine negative terminal**

The point at which the engine negative, generally the engine block, is connected to the negative of the battery.

**equalization** *see Charge Cycle*

Equalization is a controlled overcharge, which removes lead-sulfate that is not converted during normal charging. Equalization is best accomplished by using a constant current of 2-7% of battery capacity while allowing the battery voltage to rise to its highest "natural voltage". For a 12V battery this can be as high as 16.2V. The equalization cycle is continued until the specific gravity of all cells cease to continue to rise and are approximately equal. The equalization cycle should only be used on liquid electrolyte batteries and only while the operator is on the premises.

**equalizer**

A device wired across the same potential poles of a multiple bank battery bank consisting of serially wired batteries, i.e., two 12 volt batteries in series to produce 24 volts. An equalizer maintains half its input voltage at its output terminals. When loads are taken off one of the batteries in the bank at that batteries voltage, which is half of the bank voltage, the equalizer senses that battery's voltage is no longer the one half the voltage of the entire bank and the equalizer "recharges" the lower voltage battery from the higher voltage battery.

**F**

**fast, fast acting** *see also Delay*

Refers to the amount of time that a fuse can endure an over-current before blowing. Fast fuses are used to protect sensitive equipment.

**fault**

A defect in the normal circuit configuration, usually due to unintentional grounding. Commonly referred to as a short circuit.

**field**

Typically refers to a magnetic field. Specifically used when discussing the rotating electro-magnetic field associated with an alternator. By varying the field current, thus its strength, the output of the alternator may be controlled.

**float charge**

*see also Bulk, Acceptance, Equalization*

A constant voltage, well below the gassing point, that is applied to a battery to maintain its capacity. The voltage is such that neither charging nor discharging is occurring.

**frequency** *see also Hertz*

For an oscillating or varying current, frequency is the number of complete cycles per second in alternating current direction. The standard unit of frequency is the hertz, abbreviated Hz. If a current completes one cycle per second, then the frequency is 1 Hz; 60 cycles per second equals 60 Hz (the standard alternating-current utility frequency).

**fuse**

A fuse is a safety device, consisting of a strip of low-melting-point alloy, which is inserted in an electric circuit to prevent excess current from flowing. If the current becomes too high the alloy strip melts, opening the circuit.

**fusible link**

A type of fuse with a replaceable conductive alloy link that may be replaced if it “blows” due to over-current.

**G**

**galvanic corrosion**

The corrosion that occurs at the anode(s) of a galvanic cell.

**galvanic isolator**

A device installed in series with the (AC) grounding (green) conductor of the shore-power cable to effectively block low voltage DC galvanic current flow, but permit the passage of alternating current (AC) normally associated with the (AC) grounding (green) conductor. This is typically two diodes wired in parallel facing opposite directions, sized to meet full fault current.

**galvanic compatibility chart**

A list of metals and alloys arranged in order of their potentials as measured in relation to a reference electrode when immersed in seawater. The table of potentials is arranged with the anodic or least noble metals at one end, and the cathodic or most noble metals at the other.

**generator**

A rotating machine capable of generating electrical power. In the narrow definition generator refers to a DC machine and alternator refers to an AC machine. However, in common use the term generator is used to refer to AC machines as well.

**green wire**

The green wire is the non-current carrying safety grounding wire in an AC system in the United States. It is connected to an exposed metal part in the electrical system to provide a path for fault current in the case of a short circuit.

**ground fault**

*GFI (Ground Fault Interrupter)*

GFI is a generic term referring to both GFCI and GFP

*GFCI (Ground Fault Circuit Interrupter) see GFI*

A device intended for the protection of personnel that functions to de-energize a circuit, or portion thereof, within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

*GFP (Ground Fault Protector) see GFI*

A device intended to protect equipment by interrupting the electric current to the load when a fault current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protection device of that supply circuit.

**ground, ground conductor**

A point in a circuit which is at zero potential with respect to the Earth, or which is at the lowest potential in the system, (as with a floating ground).

**grounded**

The AC current carrying conductor that is intentionally maintained at ground potential, also called neutral.

**grounding, grounding conductor**

The AC conductor, not normally carrying current, used to connect the metallic non-current carrying parts of electrical equipment to the AC system and engine negative terminal, or its bus, and to the shore AC grounding conductor through the shore power cable. This term can also refer to the normally non-current carrying conductor used to connect metallic non-current carrying parts of direct current devices to the engine negative terminal, or its bus, to minimize stray current corrosion.

**ground plate**

A conductive plate, commonly sintered copper, that is placed in contact with seawater to provide a connection to earth for a boat’s ground systems.

**H**

**Hertz** *see Frequency*

Hertz is a unit of frequency of one cycle per second. It replaces the earlier term of “cycle per second (cps).” The abbreviation for Hertz is Hz.

**hot**

Hot usually refers to the ungrounded current carrying conductors in an AC system. These would typically have a voltage of 120V or 240V in the United States. The term Hot is also used to describe a circuit that is energized, and has a potential greater than ground.

**I**

**IACS**

*see International Annealed Copper Standard*

**Impressed current**

Direct current supplied by a device employing a power source external to the electrode system of a cathodic protection installation. The impressed current is used to counteract the undesired galvanic current.

**inductance**

An effect in electrical systems in which electrical currents store energy temporarily in magnetic fields before that energy is returned to the circuit.

**inductor** *see Coil*

A length of wire that is wound around a core that is used as a storage element for a magnetic field in an electric circuit.

**inrush**

The momentary steep wave front of very high current exhibited by a load on initial application of power.

**Intermittent switch rating (UL 1107)**

The two ratings in the UL marine battery switch standard are Intermittent and Continuous. Intermittent is a 5 minute rating and is based on temperature rise of various sections of the switch as the rated current is applied over a 5 minute period. The Continuous rating is the same, but the time period is 1 hour.

**International Annealed Copper Standard**

Abbreviated as IACS, this is a measurement of relative electrical conductivity that uses copper as the standard of 100%. The expression “Brass 28 IACS” would mean that the brass under discussion had 28% of the electrical conductivity of an identically sized piece of copper.

**interrupt rating (AIC)**

The fault current that a device, normally a fuse or circuit breaker, is capable of breaking without damage to the circuit.

**inverter**

An inverter converts DC power stored in a battery to AC power which is used by most household appliances.

**Ignition protection (IP)**

Devices, which operate in a potentially explosive environment, must be ignition protected. This would include engine rooms with gasoline engines. There is a very specific set of tests which a device must pass to claim ignition protection. They include operating safely in an explosive mixture of propane and air.

**isolation transformer**

A transformer that is inserted in series with the incoming AC power to provide a magnetic coupling for power between the ship’s systems and the AC grid. By magnetically coupling the power there is no direct connection by wires, which isolates the ships AC system from the AC grid.

**isolator**

Refers to two or more diodes wired in parallel and then inserted in series with the output of an alternator. This allows for the alternator to charge multiple batteries. The voltage drop across the diodes can cause incomplete charging. Isolators should not be used with alternators that use internal voltage sensing for regulation. To be properly installed the voltage sense lead must come from the house battery.

**J, K**

**kilo**

A prefix in the metric system equal to 1000 times, as in kilohertz, 1000 cycles per second.

**L**

**line** *see also Load*

The conductors that are at the supply of energy to a circuit. Line normally refers to the current carrying non-grounded conductors in an AC system.

**line loss** *see Voltage Drop*

The power loss that occurs due to amperage flowing through the resistance of conductors over their length.

**listed (UL Listed)**

Indicates that a device or component has met certain specifications as set forth by Underwriters Laboratory. Further, it means that the device or component has been tested for conformance and ‘listed’ with UL so it can use the UL logo and claim conformance to the specification.

**load** *see also Line*

A device that consumes power and does work.

**load group**

A collection of loads, which normally have similar characteristics. For example the lighting circuits might be considered a load group. Also implies that the loads are supplied by a common bus.

**lockouts (AC)**

A device allowing the selection of only one source from multiple AC sources, preventing the connection of more than one source of AC power to a bus at the same time.

**M**

**magnetic**

Displaying the characteristics of a magnet, including being able to induce current flow in a conductor when relative motion exists between them and being able to attract ferrous materials.

**main** *see also Branch Circuit*

Refers to the main circuit breaker or bus in a power distribution system. This is the input power source for the system.

**make (rating)**

The current that a breaker, switch, or relay can connect into without damaging the device.

**make before break**

Describes a switch action that connects the new circuit before disconnecting the old. This type of switch action is required for battery selector switches in order to avoid an open circuit for the engine alternator, which can cause extreme voltages that can damage the alternator and accessory electronics.

**Marine Cranking Amperes (MCA)**

MCA is the discharge load in amps, which a battery can sustain for 30 seconds at 32°F (0° C), and not fall below 1.2 volts per cell (7.2V on 12V battery). This battery rating measures a burst of energy that an engine needs to start in a cold environment.

**modified sine wave**

A marketing term to describe an AC waveform, created by an inverter that is a pulse width controlled square wave. While an improvement on the classic square wave inverter, it is not actually a sine wave or a close approximation.

**motor circuit protection**

Motors require circuit breakers or fuses that are specifically designed for their current requirements. This is because motors require a high initial surge of current to get them started.

**N**

**NEC** see *National Electrical Code*

**NEMA**

National Electrical Manufacturers Association

**N-type (alternator)**

An N-type alternator has a set of diodes, called the diode trio, which supply the positive DC potential required for the rotating field current. The actual regulator switches the negative to achieve the proper field strength to create the desired correct alternator output.

**National Electrical Code NEC**

The NEC is developed and maintained by the National Fire Protection Association which describes how residential, commercial, and RV electrical systems must be installed. The NEC is adopted, sometimes with revision, by states that also adopt the Uniform Building Code. Electrical inspections required by most building permits follow the NEC. While not required aboard boats, the NEC is a valuable guide to safe electrical systems. The goal of the NEC is personal safety and fire prevention.

**neutral** see also *Single Phase*

The neutral is the grounded current carrying conductor in a single phase, four wire, 120/240V AC system.

**neutral-to-ground bonding**

Connecting the ground and the neutral together via an electrical conductor.

**neutral-to-ground switching**

In the US, inverter/charger installations that are used in marine applications must have neutral-to-ground switching. This guarantees that the neutral and the green wire are common after the green wire connection to neutral that is achieved through the shore power cord no longer exists after the cord is disconnected and shore AC is no longer serving as the boat's AC source. There must also be only a single ground point in the AC system. This prevents a voltage differential from developing between the boat's AC neutral and the shore or genset AC neutral, which may cause an electric shock or nuisance tripping of GFI's.

**non-inverter loads**

Non-inverter loads are heavy loads that are not appropriate to run from an inverter because the load on the batteries would be excessive or illogical. They include hot water heater, electric space heat, air conditioning, heavy pumping loads, etc. A battery charger that supplies the same battery as is being used by the inverter would also be a non-inverter load.

**nuisance trip**

A circuit breaker or fuse, which trips or blows without the circuit actually being overloaded. This may be due to weak breaker or a surge current which requires a slow tripping breaker or a slow blow fuse.

**O**

**ohm**

The unit for resistance equals  $V/I = \text{volts/amps}$ . The unit of resistance is the ohm, symbol  $\Omega$ , the Greek letter Omega.

**Ohm's law**

States that the ratio of the EMF (Electromotive Force) applied to a closed circuit to the current in the circuit is a constant. That constant is the resistance of the circuit. It may be stated as  $V = IR$  (or  $E = IR$ , using E as the abbreviation of EMF whose units are volts). The unit of resistance is the ohm.

**open**

Indicates a condition in an electric circuit in which there is a break in the conductive path. The break may be intentional such as an open switch or relay or it may be unintentional such as a broken wire or a blown fuse. In any case, the continuous conductive path required for an electric circuit is not available.

**open circuit voltage**

Generally, the voltage of a source when it is not connected to a load through an electrical circuit. Specifically, the voltage of a battery when it is not delivering or receiving power. A typical value for a liquid lead acid battery is 12.8V for a fully charged battery which has not been charged or used for 24 hours. Open circuit voltage is sometimes used as an indicator of the state-of-charge of a battery.

The table below gives typical open circuit voltages for both liquid and gelled electrolyte lead-acid batteries at various states-of-charge. These voltages should be considered approximations and may vary according to manufacturer and the specific gravity of the electrolyte the battery is initially filled with.

*Typical Open Circuit Voltage After 24 Hours for Liquid and Gelled Electrolyte Batteries*

Percent Charge	Liquid Electrolyte per cell voltage	Liquid Electrolyte Nominal 12V Battery	Gelled Electrolyte per cell voltage	Gelled Electrolyte Nominal 12V Battery
100%	2.10	12.60	2.175	13.05
80%	2.09	12.54	2.13	12.78
60%	2.07	12.42	2.08	12.48
40%	2.04	12.24	2.05	12.30
20%	1.98	11.80	2.02	12.12
0%	1.95	11.70	1.98	11.88

**overcurrent**

When the current in a circuit exceeds the rating of the devices or conductors in it. Fuses and circuit breakers protect from overcurrent by opening the circuit if such a condition exists and/or persists.

**P**

**PE**

see *Protective Earth*

**P-type (alternator)**

A P-type alternator is one which one end of the coil which supplies the rotating magnetic field is connected to the negative and the regulator controls the positive side of the coil to regulate the alternator output.

**panelboard**

A collection of circuit breakers, switches, and instrumentation installed into a panel which provides the central point for power distribution and monitoring for the electrical system. May also refer to a smaller panel which is located remotely from the main panel which is used to supply loads in the adjacent area. In the marine industry they are usually called "panels", or "circuit breaker panels", or "distribution panels".

**parallel circuit**

An electrical circuit in which the positive connections are all in common and the negative connections are all in common. The voltage of the system appears across each branch of the circuit. The current varies as required by each load or source.

**parallel device**

A switch, solenoid, relay, or solid state device which is used to connect multiple batteries or busses together.

**paralleling switch**

Typically refers to a battery switch that allows multiple batteries to be connected together for engine starting. Often used to connect the battery serving the domestic system to the engine starting circuit for emergencies.

**percent of charge**

An estimate of the remaining charge in a battery. Percent of charge is very difficult to determine accurately without sophisticated microprocessor based calculations.

**Peukert's equation**

A formula that shows how the available capacity of a lead-acid battery changes according to the rate of discharge. The capacity of a battery is expressed in Amp-Hours, but the simple formula of current times hours does not accurately represent the situation. Peukert found that the equation:  $C = I^n T$  fits the observed behavior of batteries. "C" is the theoretical capacity of the battery, "I" is the current, "T" is time, and "n" is the Peukert number, a constant for the given battery. The equation captures the fact that at higher discharge current, there is less available energy in the battery.

**pigtail**

Wires which protrude from a device to connect it to the circuit. Often used in encapsulated products. Sometimes refers to a method of hooking up circuits in which a group of conductors are connected together and then one wire is connected to the circuit. This is done in order to simplify wiring.

**plate (battery)**

Flat, typically rectangular components that contain the active material, lead or lead compound, and a mechanical support structure called a grid, which also has an electrical function, carrying electrons to and from the active material. Plates are either positive or negative, depending on the active material they hold.

**polarity**

Refers to the electrical charge, which may be positive or negative. It also refers to the positive and negative terminals of a battery or load in a DC system. In AC systems it refers to the connections made to the hot and neutral. There is often a reverse polarity light that indicates if the neutral and hot are reversed.

**polarized system**

An electrical system in which the positive and negative or the hot and neutral must be connected in a particular way and cannot be switched. Sometimes there are mechanical preventions to insure the correct polarity. For example, in an AC plug the physical configuration of the plug and receptacle force a polarized connection.

**pole**

Indicates a conductive path in a switch or relay. Switches that are single pole have one conductive path, switches that are two pole have two conductive paths. Also refers to the magnetic poles on an electromagnet or a permanent magnet.

**potential**

The voltage across a circuit element. Implies the potential to do work.

**power**

Electrical power is the rate at which electrical energy is converted to another form, such as motion, heat, or an electromagnetic field. The common symbol for power is the uppercase letter P. The standard unit is the watt, symbolized by W. In utility circuits, the kilowatt (kW) is often specified instead; 1 kW = 1000W.

Power in a direct current (DC) circuit is equal to the product of the voltage in volts and the current in amperes. This rule also holds for low-frequency

alternating current (AC) circuits in which energy is neither stored nor released. At high AC frequencies, in which energy is stored and released (as well as dissipated or converted), the expression for power is more complex.

In a DC circuit, a source of  $V$  volts, delivering  $I$  amperes, produces  $P$  watts according to the formula:  $P = VI$

When a current of  $I$  amperes passes through a resistance of  $R$  ohms, then the power in watts dissipated or converted by that component is given by:  $P = I^2R$

When a potential difference of  $V$  volts appears across a component having a resistance of  $R$  ohms, then the power in watts dissipated or converted by that component is given by:  $P = V^2/R$

**power factor**

In an AC, circuit loads other than resistance shift the phase angle between the voltage and the current. This shift is the result of energy being stored and released in inductors and capacitors. Since this storage does not represent a consumption of power, a power measurement must take the relative phase of voltage and current into account. The ratio of actual power to the simple product of measured voltage and measured current is called the power factor. Modern electronic devices such as microwave ovens, battery chargers, and computers do not draw current in the same sinusoidal wave shape as the incoming voltage. These distorted wave shapes are also less effective at delivering power and give rise to a power factor less than unity because of the additional frequencies present in the current waveform.

**propagation**

The transmission of an electrical or electromagnetic signal through a medium such as air or a conductor.

**Q, R**

**RCBO or RCCB**

Residual Current Circuit Breaker is a circuit breaker that includes an overcurrent trip mechanism like a conventional breaker and includes a leakage current trip that responds to current returning through a ground path instead of the neutral conductor or the other wires of a circuit with multiple live lines. The principle is the same as a Ground Fault Circuit Interrupter but RCCB's typically have a ground fault limit of 30mA or 100mA instead of 6mA of a GFCI used for personnel protection. GFCI's are generally useful for protecting a single load or a single branch circuit but are too sensitive for use as main circuit breakers. RCCB's are used for main circuit protection in Europe for boats, houses and commercial power distribution. Without this additional protection, as much as 40 Amps can flow in the ground wire, or into the water without tripping a conventional main circuit breaker.

**RCD see also Residual Current Device**

Recreational Craft Directive - European Directive 94/25-EC relating to recreational craft.

Following are special definitions related to the RCD:

**CD**

Committee Draft – the first draft circulated for comment by ISO Small Craft Technical Committee Working Group developing the standard.

**CEN**

The European Committee for Standardization.

**DIS**

Draft International Standard – an advanced draft where comments on the CD have been taken into account. Minor comments accepted by the Working Group will be incorporated in the FDIS, major changes will result in a second circulation as a DIS.

**EN**

European Standard (Norme).

**FDIS**

Final Draft International Standard – the last voting stage where standard bodies can only vote “yes” or “no” and the only changes will be editorial.

**ICOMIA**

The International Council of Marine Industry Associations – the International Marine Industry Trade Association, which represents 24 national marine industry associations. That includes virtually all countries with an active marine industry in Europe, North America, Asia and Australia. Its officers and members represent its members' views at the EU Commission, ISO, and CEN and its members' representatives are actively involved in all the RSG Standards Working Groups.

**ISO**

International Standards Organization

**PREN**

The abbreviation used by CEN to identify a draft standard at any stage.

**WG**

Working Group – the committee whose members have been nominated by their national standards body to develop any new standard required by the ISO Small Craft Tec. Committee (TC188) one of whom is chosen to act as the Convenor (Chairman/Secretary) by the TC188 members.

**LIST OF EUROPEAN UNION (EU) & EUROPEAN ECONOMIC AREA (EEA) NATIONAL STANDARDS BODIES**

Austria	ON	Italy	UNI
Belgium	IBN	Luxembourg	ITM
Denmark	DS	Netherlands	NNI
Finland	SFS	Norway*	NSF
France	AFNOR	Portugal	IPQ
Germany	DIN	Spain	AENOR
Greece	ELOT	Sweden	SIS
Iceland*	STRI	Switzerland	SNV
Ireland	NSIA	UK	BSI

\* EEA countries – whose national standards bodies are participants in CEN debates, but have a non-voting status.

**recognized (UL recognized)**

A device that is UL Recognized differs from a device that is UL Listed. A Recognized device is expected to be installed within a larger assembly by a manufacturer, not in the field, and this larger assembly is then expected to be tested by UL. The UL Recognition then allows UL to skip testing of the specific embedded Recognized component. UL Recognition has little value for end users installing devices in the field.

**rectifier**

A device that allows current to flow in only one direction, such as a diode. Used to convert, or rectify AC current into DC.

**regulator (voltage regulator)**

A device, which uses a feedback loop to control the output of an alternator or other source. By measuring the output voltage and controlling the alternator field current, for example, the regulator is able to continuously adjust the alternator output to the desired voltage.

**reserve capacity (battery)**

RC is the number of minutes a new, fully charged battery at 80°F will sustain a discharge load of 25 amps to a cut-off voltage of 1.75 volts per cell (10.5V on 12V battery). This battery rating measures more of a continuous load on the battery.

**residual current device**

An RCD is an electrical safety device specially designed to immediately switch the electricity off when electricity is “leaking” to earth is detected at a level harmful to electrical equipment. In most countries using 50Hz power, an RCD is considered to provide personnel protection.

An RCD offers a high level of personal protection from electric shock when installed on a boat because the additional grounding through hull fittings is sufficient to trip and RCD during a fault. RCD's offer a backup level of safety if the green ground wire of a shore cable or a galvanic isolator has failed. Fuses or overcurrent circuit breakers do not offer the same level of personal protection against faults involving current flow to earth. RCDs are designed to operate within 10 to 50 milliseconds and to disconnect the electricity supply when they sense harmful leakage, typically 30 milliamps. See also GFI or GFCI devices which are similar in nature, but trip at 5mA for personnel protection. GFCI devices are required by ABYC standards for AC outlets in galleys, on deck and in machinery spaces. These cannot usually be used for the entire system because normal stray currents can cause nuisance tripping.

**resistance**

The opposition to the flow of current in an electric circuit as defined by Ohm's law. The unit of resistance is the ohm, symbol  $\Omega$ , the Greek letter Omega.

**reverse polarity**

Describes a situation where the neutral and hot wires of an AC system are reversed. Most AC panels have an indicator to announce this condition, as it can be very dangerous.

**RMS (Root-mean-square)**

Root-mean-square (RMS) refers to the most common mathematical method of defining the effective voltage or current of an AC sine wave.

To determine RMS value, three mathematical operations are carried out on the function representing the AC waveform:

- (1) The square of the waveform function (usually a sine wave) is determined.
- (2) The function resulting from step (1) is averaged over time.
- (3) The square root of the function resulting from step (2) is found.

In a circuit whose impedance consists of a pure resistance, the RMS value of an AC wave is often called the effective value or DC-equivalent value. For example, if an AC source of 100 volts RMS is connected across a resistor, and the resulting current causes 50 watts of heat to be dissipated by the resistor, then 50 watts of heat will also be dissipated if a 100-volt DC source is connected to the resistor.

For a sine wave, the RMS value is 0.707 times the peak value, or 0.354 times the peak-to-peak value. Household utility voltages are expressed in RMS terms. A so-called “117-volt” AC circuit has a voltage of about 165 volts peak (pk), or 330 volts peak-to-peak (pk-pk).

**S**

**SAE (Society of Automotive Engineers)**

An organization which sets standards for various equipment used in the automotive industry. Since much of the basic equipment used in the marine industry originates in the automotive industry it can be a relevant specifications body for the marine industry as well.

**SAE wire gauge**

Wire sizes as specified by the SAE, specifically for stranded wire, similar to the AWG, see also AWG. The same gauge in SAE wire has a smaller conductor than in AWG wire.

**sacrificial anode**

A less noble metal intentionally connected to form a galvanic cell with a more noble metal for the purpose of protecting the more noble metal from corrosion. Most commonly zinc.

**safety green (ground) wire**

The non-current carrying conductor in a three wire 120V or four wire 240V AC circuit, it provides a safe path for fault current. See also green ground wire.

**sealed lead-acid**

see *Gel Cell self-limiting*

A device whose ability to limit output power regardless of input power is intrinsic to its design.

**sheath**

A material used as a continuous protective covering around one or more insulated conductors. The ABYC uses this term when discussing the allowable length of a conductor before it must have over current protection. The distance is extended if it is in a sheath.

**shore power**

AC utility power that is available when plugged into an outlet that is supplied from the main utility system.

**short circuit**

A conductive path of zero resistance. Typically refers to an unintentional connection between two conductors of opposite polarity. If a voltage is applied to a short circuit the current becomes very large and can start a fire, thus the need for short circuit, or overcurrent, protection in the form of fuses or circuit breakers.

**shunt**

A shunt resistor is a precise, low Ohm resistor that is temperature stable. It is used as a current "sensor" by using a millivolt meter to measure the voltage drop across it. Large current shunts are commonly made of one or more strips of manganin, a copper alloy capable of carrying high currents, that are soldered between machined blocks of brass with connecting bolts.

Shunts are rated according to the number of Amps they are capable of carrying and the voltage which is generated across the shunt when the rated current is being passed through it. Common shunt ratings include 100A 100mV or 500A 50mV. The resistance can be calculated by using Ohms Law,  $V=IR$ ,  $50mV=500A(R)$ , therefore  $R=0.1m\Omega$ , or  $0.0001\Omega$ . This is a very small value of resistance; it must be in order to minimize the power loss when large currents are flowing.

The shunt normally has two separate screws with which the sense leads are attached. It is important to realize that the integrity of these connections are critical to accurate measurement and should not be used as current carrying connections.

**sine wave**

A waveform that can be expressed as the graph of the equation  $y = \sin x$ . The utility AC power is a sine wave.

**single phase**

The typical 120/240V AC system in the United States is a single phase system, meaning that the current flow in the two conductors is in phase or that they both cross zero at the same time.

**skin effect**

Skin effect refers to the phenomena of conductors' propagating AC current more efficiently on the conductors' surface than in its interior.

**slow, slow blow** see also *Delay*

A fuse that is a slow blow has a longer delay when subjected to over-current, before it fails. Slow blow fuses are required for loads that have high starting surges, like motors.

**solenoid (relay)**

An electromechanical device that is used to switch large currents. It consists of a coil of wire and a moving contact that makes an electrical connection when the coil of wire is energized.

**source isolation (AC)**

The arrangement of multiple AC power sources in such a manner that two AC sources cannot be connected to the same circuit simultaneously.

**source selector**

A switch or breaker configuration, which allows the user to pick which source to have connected to the bus. Typically used in AC systems with multiple sources such as shore power and one or more generators.

**speed** see *Delay*

Indicates how fast circuit protection devices react, specifically with respect to over circuit breakers and fuses.

**square wave**

An electrical waveform in which the current quickly goes from zero to its peak value in a step fashion. This is typical of inexpensive inverters.

**starting bank**

An arrangement of batteries that is designated for the function of engine starting.

**storage battery**

An electrochemical device capable of storing energy and releasing it and then able to be re-charged and repeat the process.

**stray current**

Unwanted current flows which occur due to a partial short circuit.

**stray current corrosion**

Corrosion that results when current from a battery or other external electrical (DC) source causes a metal in contact with an electrolyte to become anodic with respect to another metal in contact with the same electrolyte.

**sulfation**

Sulfation is the formation or deposit of lead sulfate on the surface and in the pores of the active material of the batteries' lead plates. If the sulfation becomes excessive and forms large crystals on the plates, the battery will not operate efficiently and may not work at all. Common causes of battery sulfation are standing a long time in a discharged condition, operating at excessive temperatures, and prolonged under or over charging.

**surge**

A large amount of current during the initial starting phase of a motor for example.

**surge capacity**

The measurement of the ability to withstand surge currents without damage.

**surge current** see also *Continuous Current*

The pulse of current that is associated with the initial large current required to start an electric motor, large resistive loads, and engine cranking.

**switch**

An electro-mechanical device that is intended to open an electrical circuit and thus turn a load or source on or off.

**switchboard**

see *Panelboard*

**T**

**terminal**

A connection point or device for an electrical circuit. A terminal strip is a series of screws which may or may not be connected to which wires are connected. Also refers to the connecting device which may be crimped on the end of a wire to enable it to be connected to the circuit with a screw, such as a ring terminal.

**terminal studs**

A threaded bolt onto which ring terminals may be placed and then fastened with a nut. Normally used for high current connections.

**thermal**

In a marine context thermal most commonly refers to a thermal circuit breaker, which uses the thermal effect of excess current flow to create differential expansion in a bi-metallic blade to open a circuit.

**time-current curve** see also *Delay*

A curve which depicts the relationship between the amount of current a fuse or breaker can hold with respect to time before opening the circuit.

**tin plating**

A plating of the element tin, which prevents corrosion. Commonly used to plate copper components such as a power bus.

**toggle** see also *Pole*

A switch which has a handle type actuator that can be placed in, at the most, three positions.

**transfer switch, AC**

see *source selector, Source Isolation*

An electrical relay or manual switch which selects an AC source alternative, such as a generator, shore power, or inverter.

**transformer**

see *Isolation Transformer*

**trip free**

A circuit breaker designed to trip when subjected to a fault current, even if the reset lever is held in the ON position.

**U, V**

**ungrounded conductor**

Any conductor that is not connected to the Earth ground system

**volt (voltage)**

The unit of electric potential and electromotive force, equal to the difference of electric potential between two points on a conducting wire carrying a constant current of one ampere when the power dissipated between the points is one watt.

**volt-amps**

The product of volts and amps, which is watts in a DC system and the apparent power in an AC system.

**voltage drop**

see *line loss*

**W**

**watt**

The unit of power which for a DC circuit is equal to volts times amps.

**weatherproof**

Constructed or protected so that exposure to the weather will not interfere with successful operation in rain, spray, and splash.

**wire amperage rating**

The current a conductor can carry under a set of specified conditions such as open air, in an enclosure, and at a specified temperature.

**wire sizing**

The process of selecting the appropriate sized conductor for the amount of current to be carried while considering the length of the circuit.

**withstand voltage**

The maximum voltage level that can be applied between circuits or components without causing insulation breakdown.

**X, Y, Z**

PN	PAGE	PN	PAGE	PN	PAGE	PN	PAGE	PN	PAGE	PN	PAGE
1001	116	2812	113	3401	47	3565	80, 81	4137	40	5120	37
1002	116	2904	113	3402	47	3566	79	4138	54	5121	37
1003	116	2908	113	3403	46, 47	3567	79	4140	86	5122	35-36
2001	115	2912	113	3405	80, 81	3568	78, 79	4150	54	5123	35-36
2002	115	3000	16-17	3406	80, 81	3569	78, 79	4151	54	5124	35-36
2003	115	3001	16-17	3407	80, 81	3570	80, 81	4152	54	5125	35-36
2010	115	3002	16-17	3408	84, 85	3571	80, 81	4153	54	5126	35-36
2011	115	3003	16-17	3409	80, 81	3572	80, 81	4154	54	5127	35-36
2101	115	3023	47	3411	82, 83	3573	78, 79	4155	54	5128	35-36
2102	115	3025	47	3412	80, 81	3574	79	4215	89	5129	35-36
2103	115	3027	80, 81	3458	78, 79	3575	78, 79	4216	89	5130	35-36
2104	110	3029	80, 81	3459	78, 79	3576	78, 79	4217	89	5131	35-36
2105	109	3032	67, 79	3460	82, 83	3577	78, 79	4218	89	5132	35-36
2106	109	3043	80, 81	3461	82, 83	3578	82, 83	4302	50, 51	5133	35-36
2107	110	3058	82, 83	3462	78, 79	3579	82, 83	4304	50, 51	5134	36
2201	114	3059	82, 83	3463	80, 81	3580	82, 83	4306	50, 51	5135	36
2202	114	3061	67, 79	3464	80, 81	3581	82, 83	4308	50, 51	5136	36
2203	114	3068	46, 47	3465	80, 81	3582	82, 83	4312	50, 51	5137	36
2204	114	3074	80, 81	3466	79	3583	82, 83	4314	50, 51	5138	58
2205	114	3076	80, 81	3467	79	3584	82, 83	4316	50, 51	5139	58
2206	114	3077	66, 80, 81	3468	78, 79	3585	80, 81	4318	50, 51	5140	58
2207	114	3079	66, 80, 81	3469	78, 79	3586	80, 81	4374	48, 49	5141	58
2208	114	3081	47	3470	80, 81	3587	80, 81	4376	48, 49	5142	58
2300	108	3082	47	3471	80, 81	3588	80, 81	4384	48, 49	5143	58
2301	106, 108	3084	84, 85	3472	80, 81	3589	79	4386	48, 49	5161	36
2302	108	3085	84, 85	3473	78, 79	3594	78, 79	5000	34	5162	36
2303	108	3086	84, 85	3474	79	3595	67, 79	5001	34	5163	36
2304	106	3095	84, 85	3475	78, 79	3596	78, 79	5002	37	5164	35-36
2305	106	3096	47	3476	78, 79	3598	67, 78, 79	5003	36	5165	35-36
2306	106	3097	82, 83	3477	78, 79	3599	78, 79	5004	35	5200	59
2402	111	3099	80, 81	3478	82, 83	4001	117	5005	35	5201	59
2404	111	3127	80, 81	3479	82, 83	4005	117	5006	58	5202	59
2406	111	3129	80, 81	3480	82, 83	4006	117	5007	37	5203	59
2408	111	3132	67, 79	3481	82, 83	4008	117	5015	56	5204	59
2410	111	3143	80, 81	3482	82, 83	4009	117	5018	56	5205	59
2502	111	3158	82, 83	3483	82, 83	4010	117	5021	54, 87	5206	59
2504	111	3159	82, 83	3484	82, 83	4011	117	5025	57	5207	59
2506	111	3161	67, 79	3485	80, 81	4012	117	5026	57	5208	59
2508	111	3165	82, 83	3486	80, 81	4013	117	5028	57	5209	59
2510	111	3174	80, 81	3487	80, 81	4014	117	5029	57	5210	59
2512	111	3176	80, 81	3488	80, 81	4015	117	5030	57	5211	59
2602	112	3177	66, 80, 81	3489	79	4016	117	5031	57	5212	59
2604	112	3179	66, 80, 81	3494	78, 79	4017	117	5033	57	5213	59
2606	112	3184	84, 85	3495	67, 79	4021	118	5034	57	5214	59
2608	112	3185	84, 85	3496	78, 79	4022	118	5101	34	5215	59
2610	112	3186	84, 85	3498	67, 78, 79	4023	118	5102	34	5216	59
2701	107	3195	84, 85	3499	78, 79	4026	88	5103	34	5217	59
2702	107	3197	82, 83	3505	80, 81	4027	88	5104	34	5218	59
2707	108	3199	80, 81	3506	80, 81	4028	88	5105	34	5219	59
2708	110	3264	46, 47	3507	80, 81	4029	88	5106	34	5220	59
2709	107	3265	82, 83	3508	84, 85	4031	88	5107	34	5221	59
2710	107	3375	46, 47	3509	80, 81	4100	88	5108	34	5222	59
2711	109	3376	47	3511	82, 83	4110	33, 64, 73	5112	37	5223	59
2714	106	3377	46, 47	3512	80, 81	4111	86	5113	37	5224	59
2715	108	3378	46, 47	3559	78, 79	4125	88	5114	37	5225	59
2720	107	3379	46, 47	3560	82, 83	4126	88	5115	37	5226	59
2722	107	3380	47	3561	82, 83	4130	88	5116	37	5227	59
2723	107	3381	46, 47	3562	78, 79	4131	88	5117	37	5228	59
2804	113	3382	46, 47	3563	80, 81	4135	40	5118	37	5229	59
2808	113	3385	47	3564	80, 81	4136	40	5119	37	5230	59



PN	PAGE	PN	PAGE	PN	PAGE	PN	PAGE	PN	PAGE	PN	PAGE
5231	59	7055	40	7230	41, 63, 72	7348	63, 72	8028	101	8177	66, 80, 81
5232	59	7056	40	7232	63, 72	7349	63, 72	8029	80, 81	8179	66, 80, 81
5233	59	7057	40	7233	63, 72	7350	32, 74	8030	90	8184	84, 85
5234	59	7058	40	7234	63, 72	7351	32, 74	8031	90	8185	84, 85
5235	59	7059	40	7235	63, 72	7352	32, 74	8032	67, 79	8186	84, 85
5236	59	7060	40	7236	63, 72	7353	32, 74	8033	87	8195	84, 85
5237	59	7061	40	7237	63, 72	7354	32, 74	8034	87	8197	82, 83
5238	59	7100	30	7238	63, 72	7355	32, 74	8035	86	8199	80, 81
5239	59	7102	30	7239	63, 72	7365	65, 74	8037	86	8200	86
5240	59	7104	30	7240	63, 72	7370	77	8038	101	8204	86
5241	59	7105	30	7241	63, 72	7371	77	8039	90	8205	86
5242	59	7106	30	7242	63, 72	7372	77	8041	101	8206	86
5243	59	7107	30	7244	32, 74	7373	77	8043	80, 81	8207	86
5244	59	7108	30	7246	32, 74	7374	77	8051	102	8208	86, 105
5245	59	7109	30	7248	32, 74	7374	77	8053	53	8209	86
5246	59	7110	30	7250	32, 74	7400	43, 73	8054	53	8210	86
5301	22	7111	30	7250I	32	7401	43, 73	8058	82, 83	8211	86
5302	22	7112	30	7251	65, 74	7402	43, 73	8059	82, 83	8212	86
5510e	14-15	7113	30	7254	65, 74	7403	43, 73	8061	67, 79	8214	90
5511e	14-15	7114	30	7256	65, 74	7404	43, 73	8065	87	8216	105
6005	12-13	7115	30	7258	65, 74	7405	43, 73	8066	87	8217	90
6006	12-13	7135	31	7260	63, 72	7406	43, 73	8067	90	8218	55
6007	12-13	7136	31	7262	32	7407	43, 73	8068	46, 47	8219	55
6010	12-13	7137	31	7263	32	7408	43, 73	8069	87	8220	55
6011	12-13	7138	31	7264	32	7425	43, 73	8072	87	8221	55
6337	69	7139	31	7265	32	7426	43, 73	8073	103	8222	55
6575	89	7140	31	7266	32	7427	43, 73	8074	80, 81	8230	22, 23, 55
7000	30	7141	31	7267	32	7428	43, 73	8076	80, 81	8231	55
7002	30	7142	31	7268	32	7429	43, 73	8077	66, 80, 81	8232	24, 25, 55
7004	30	7143	31	7269	32	7430	43, 73	8079	66, 80, 81	8233	55
7005	30	7144	31	7270	32	7431	43, 73	8080	19	8234	55
7006	30	7145	31	7271	32	7432	43, 73	8081	47	8235	98, 99
7007	30	7146	31	7287	65, 74	7433	43, 73	8082	47	8236	99
7008	30	7147	31	7288	65, 74	7450	33	8084	84, 85	8237	97
7009	30	7148	31	7289	65, 74	7451	33	8085	84, 85	8238	96, 97
7010	30	7198	30	7290	65, 74	7452	33	8086	84, 85	8239	96, 97
7011	30	7199	30	7291	41	7475	33	8087	33, 65	8240	101
7012	30	7200	41, 63, 72	7292	41	7476	33	8088	33, 65	8242	103
7013	30	7201	41, 63, 72	7293	41	7477	33	8089	33, 65	8243	101
7014	30	7202	41, 63, 72	7294	63, 72	7501	104	8095	84, 85	8244	100
7015	30	7204	41, 63, 72	7295	63, 72	7502	104	8096	47	8245	100
7035	31	7205	41, 63, 72	7299	41, 63, 72	7503	104	8097	82, 83	8246	100
7036	31	7206	41, 63, 72	7300	43, 64, 73	7505	104	8099	80, 81	8247	96, 97
7037	31	7208	41, 63, 72	7301	43, 64, 73	7600	24, 26	8127	80, 81	8248	98, 99
7038	31	7209	41, 63, 72	7302	43, 64, 73	7900	13	8129	80, 81	8250	101
7039	31	7210	41, 63, 72	7303	43, 64, 73	7901	13	8132	67, 79	8251	98, 99
7040	31	7212	41, 63, 72	7304	43, 64, 73	7902	13, 15, 17	8134	87	8252	101
7041	31	7213	41, 63, 72	7305	43, 64, 73	8003	101	8143	80, 81	8253	101
7042	31	7214	41, 63, 72	7306	43, 64, 73	8005	101	8158	82, 83	8254	101
7043	31	7216	41, 63, 72	7307	43, 64, 73	8013	102	8159	82, 83	8255	103
7044	31	7217	41, 63, 72	7308	43, 64, 73	8014	102	8161	67, 79	8256	103
7045	31	7218	41, 63, 72	7320	64, 73	8015	102	8165	82, 83	8257	103
7046	31	7220	41, 63, 72	7321	64, 73	8016	101	8166	87	8258	100
7047	31	7221	41, 63, 72	7322	64, 73	8017	101	8167	87	8259	55
7048	31	7222	41, 63, 72	7323	64, 73	8018	101	8169	87	8260	55
7050	40	7224	41, 63, 72	7324	64, 73	8019	101	8171	87	8261	53
7051	40	7225	41, 63, 72	7325	64, 73	8022	101	8172	87	8262	53
7052	40	7226	41, 63, 72	7326	64, 73	8023	47	8173	87	8263	53
7053	40	7228	41, 63, 72	7327	64, 73	8025	47	8174	80, 81	8264	46, 47
7054	40	7229	41, 63, 72	7347	41, 63, 72	8027	80, 81	8176	80, 81	8265	82, 83

PN	PAGE	PN	PAGE	PN	PAGE	PN	PAGE
8266	55	8407	80, 81	8569	78, 79	9003C	14-15
8267	55	8408	84, 85	8570	80, 81	9004C	14-15
8268	55	8409	80, 81	8571	80, 81	9009	68
8270	24, 25	8410	97, 102	8572	80, 81	9010	70
8271	52	8411	82, 83	8573	78, 79	9011	68
8272	52	8412	80, 81	8574	79	9012	23
8273	52	8458	78, 79	8575	78, 79	9019	69
8274	52	8459	78, 79	8576	78, 79	9030	117
8275	55	8460	82, 83	8577	78, 79	9031	117
8278	55	8461	82, 83	8578	82, 83	9038	117
8280	18	8462	78, 79	8579	82, 83	9039	117
8282	55	8463	80, 81	8580	82, 83	9040	117
8283	55	8464	80, 81	8581	82, 83	9041	117
8284	55	8465	80, 81	8582	82, 83	9077	70
8285	55	8466	79	8583	82, 83	9093	69
8286	55	8467	79	8584	82, 83	9001E	14-15
8287	55	8468	78, 79	8585	80, 81	9002E	14-15
8288	55	8469	78, 79	8586	80, 81	9003E	14-15
8289	55	8470	80, 81	8587	80, 81	9004E	14-15
8290	55	8471	80, 81	8588	80, 81	9112	25-26
8291	105	8472	80, 81	8589	79	9174	117
8292	55	8473	78, 79	8594	78, 79	9175	117
8293	55	8474	78, 79	8595	67, 79	9176	117
8294	55	8475	78, 79	8596	78, 79	9177	117
8295	55	8476	79	8598	67, 78, 79	9216	112
8296	55	8477	78, 79	8599	78, 79	9217	112
8297	55	8478	82, 83	8600	67	9218	112
8298	55	8479	82, 83	8602	67	9228	103
8299	55	8480	82, 83	8604	66, 76	9229	103
8357	68	8481	82, 83	8605	66, 76	9230	103
8358	70	8482	82, 83	8606	66, 76	9231	103
8359	68	8483	82, 83	8607	66, 76	9233	103
8361	70	8484	82, 83	8610	76	9353	100
8363	69	8485	80, 81	8611	76	9354	100
8365	68	8486	80, 81	8612	76	9630	100
8366	70	8487	80, 81	8613	76		
8367	68	8488	80, 81	8614	76		
8369	69	8489	79	8615	76		
8370	18	8494	78, 79	8616	76		
8371	52	8495	67, 79	8617	76		
8372	52	8496	78, 79	8618	76		
8373	52	8498	67, 78, 79	8619	76		
8374	52	8499	78, 79	8620	76		
8375	46, 47	8505	80, 81	8621	76		
8376	47	8506	80, 81	8675	45		
8377	46, 47	8507	80, 81	8676	45		
8378	46, 47	8508	84, 85	8677	45		
8379	46, 47	8509	80, 81	8678	45		
8380	47	8511	82, 83	8679	45		
8381	46, 47	8512	80, 81	8680	45		
8382	46, 47	8559	78, 79	8684	84, 85		
8383	87	8560	82, 83	8685	84, 85		
8384	87	8561	82, 83	8686	20		
8385	47	8562	78, 79	8687	20		
8386	69	8563	80, 81	8689	21		
8401	47	8564	80, 81	8690	20		
8402	47	8565	80, 81	8691	20		
8403	46, 47	8566	79	8693	21		
8405	80, 81	8567	79	9001C	14-15		
8406	80, 81	8568	78, 79	9002C	14-15		