

P O C K E T

GUIDE

Electrical Energy 101





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
Electrical Energy 101



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Introduction

This pocket guide is divided into six chapters. The right pages of each chapter are marked with a tab that lines up with the thumb index tabs on the right of this page.

You can quickly find the first page of each chapter by flipping through the pages of this Pocket Guide or by using the Table of Contents which follows.

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Fundamentals

Fundamentals

What is Electrical Power?

The time rate at which electrical energy is emitted, transferred, or received. In the USA, electrical power is typically expressed in watts.

What is a Watt?

The watt is a unit of measure for electrical power. Wattage is the product of the electrical force (voltage) and the electrical current (amperes) in an electrical circuit.

What is a kW (kilowatt)?

One thousand watts (1,000). A form of measurement for the quantity of electricity needed to control given equipment.

What are kWhrs or kWh?

Kilowatt hours. This is the time-rate measurement for the consumption of energy. If a device consumes 1000 Watts of power for 1 hour, it has consumed 1 kilowatt hour (kWh). Additionally, 500 Watts for 2 hours is also 1 kWh.

What is a MW (megawatt)?

One-thousand kilowatts (1,000 kW) or one million (1,000,000) watts.

What is a MWh?

(Megawatt Hour) One thousand kilowatt hours.

What is Electric Current?

A flow of electricity through a conductor.

Fundamentals

What is an Electrical Circuit?

A circuit is a closed path through which an electric current flows. It is an arrangement of interconnected electronic components that can perform specific functions upon application of proper voltages and signals. If you think of your home, typically each room is serviced by a dedicated electrical circuit, protected by a circuit breaker in the main service panel to allow you to turn sections of your home ON or OFF without affecting the entire house.

What is an Ampere (aka Amp)?

A unit of measure for the flow of electrons (current) within an electrical wire. It is analogous to the flow of water (gallons/sec) in a water pipe. Common electrical circuits used in homes are typically rated at 15 or 20 Amps.

What is Electromotive Force?

The voltage generated by a battery or by magnetic force. Refers to the potential, or energy per unit of charge.

What is a Volt?

A unit of measure for electrical potential difference or electromotive force in an electrical circuit. It is analogous to the amount of water pressure (pounds per square inch) in a water line. Electrical systems of most US houses and offices have 120 volts.

What is a kV (kilovolt)?

One thousand (1,000) volts. Electrical lines in housing areas usually are 12kV (12,000 volts).

Fundamentals

What is an Ohm?

A unit of measure for the resistance in an electrical circuit.

What is Ohm's Law?

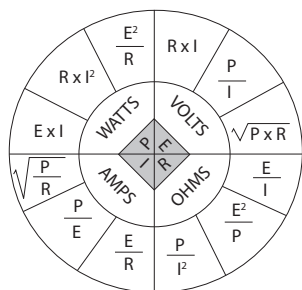
A law and mathematical formula stating the current in an electric circuit is inversely proportional to the resistance of the circuit and is directly proportional to the electromotive force in the circuit. Ohm's law applies strictly to linear constant-current circuits.

(P) Power, measured in watts.

(E) Voltage, measured in volts

(I) Current, measured in amperes or amps

(R) Resistance, measured in ohms



There are three basic Ohm's Law formulas:

$$I = E/R \quad \text{Amperes} = \text{Volts} / \text{Ohms}$$

$$R = E/I \quad \text{Ohms} = \text{Volts} / \text{Amperes}$$

$$E = I \times R \quad \text{Volts} = \text{Amperes} \times \text{Ohms}$$

Fundamentals

What is a Conductor?

A conductor (aka “a wire”) is a substance or body that allows a current of electricity to pass continuously along it. Conductors may be solid or stranded, that is, built up by an assembly of smaller solid conductors. For example, metal wires and cables are frequently used for carrying electric current.

American Wire Gauge	mm	Area Cir. Mils.	Current Rating Amps (for ventilated cable rack installation)
18	.75	1,620	5
16	1.5	2,580	10
14	2.5	4,110	15
12	4	6,530	20
10	6	10,380	30
8	10	16,510	45
6	16	26,240	65
4	25	41,740	85
2	35	66,360	115
1	50	83,690	130
0		105,600	150

What is Electrical Resistance?

The degree to which an object opposes the flow of electrical current. The result of resistance is that the voltage of a circuit will decrease as the current flows through the circuit. This is similar to the way water flow decreases due to friction as it passes through a hose.

What is Resistance?

The ability of all conductors of electricity to defy the flow of current, turning some of it into heat. Resistance relies on the cross section of the conductor (the smaller the cross section, the superior the resistance) and its temperature (the hotter the cross section, the more the resistance).

Fundamentals

What is a Resistor?

A electrical component that implements resistance as a circuit element. Resistance is the opposition to the passage of current through a conductor. Measured in Ohms.

What is Capacitance?

The ability of an object to store an electrical charge. Measured in Farads.

What is a Capacitor?

A device with the primary purpose of introducing capacitance into an electric current. It is an electronic component, consisting of two or more isolated plates, used to temporarily store electrical energy. It is similar to a reservoir storing the spring runoff for use later in the summer months.

What is Inductance?

The ability of an object to resist a change in electrical current by generating an electromagnetic field. Measured in Henrys.

What is an Inductor?

An electrical component that stores energy in its magnetic field. An Inductor is typically made of a wire or other conductor wound into a coil, to increase the magnetic field.

What is a Henry?

The inductance of a closed circuit in which an electromotive force of one volt is produced when the electric current in the circuit varies uniformly at a rate of one ampere per second.

What is a Diode?

A diode is a semiconductor device. Since electric current passes through it in only one direction, the diode is ideal for use as a rectifier (AC in one side, DC out on the other).

Fundamentals

What is an LED?

Light-Emitting Diodes are used as indicator lamps in many devices, especially for lighting. LED's are based on the semiconductor diode and present many advantages over incandescent lights including lower energy consumption and longer life span.

Where does electrical power come from? Where does it go?

Electrical power is typically generated by converting other forms of energy into electricity. For example, the energy in coal, natural gas and nuclear reactors are all used to produce steam that is used to drive generators that produce electricity. Electricity is delivered to homes and businesses over transmission wires often referred to as "The Grid." The potential for work contained in the electricity delivered to our homes and businesses is then consumed by a wide variety of electrical devices to perform work. For example, a space heater will convert 1000 Watts of electrical energy into heat to raise the temperature of a cold room.

What is Load?

The amount of electric power supplied to meet one or more final user's needs. Also refers to an end-use device or an end-use customer that uses power.

What is Load Diversity?

A situation that subsists when the peak demands of several electric customers happen at dissimilar times. This is the goal of "load molding" strategies, which curbs the total capacity requirements of a utility.

Fundamentals

What is Load Factor?

The difference between the amount of electricity consumed by a customer during a specified time and the amount that would have been used if the usage had stayed at the consumers highest demand level during the whole time. The term is also used to mean the percentage of capacity of an energy facility (such as power plant or gas pipeline) that is employed in a specific time period.

What is Load Management?

Steps taken to decrease power demand at highest load times or to move some of it to off-peak times. This may refer to peak hours, peak days or peak seasons. The main disruption to electric peaks is air-conditioning usage, which is therefore a major target for load management labors. Load management may be pursued by convincing consumers to change behavior or by using equipment that regulates some electric consumption.

What is Partial Load?

An electrical demand that only uses a fraction of the available electrical power.

What is Distribution?

Electricity delivered to a location through low voltage distribution lines.

What is Distribution Service?

The delivery of electricity directly to a home or business.

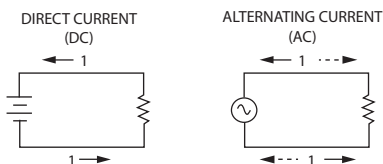
Fundamentals

What is DC (Direct Current) Power?

An electric current that flows in only one direction. Direct current is produced by sources such as batteries and solar cells.

What is AC (Alternating Current) Power?

An electrical current that reverses direction in a circuit at regular intervals. Alternating current is the type of electricity produced and delivered by the utility (power company) to your wall plug. Electrical power delivered in the USA alternates current at a frequency of 60 cycles per second (Hertz). Utilities deliver AC power instead of DC power because transformers can be used to easily convert the voltage from one circuit to another. Utilities typically deliver electricity over long distances from power plants to neighborhoods using high voltage transmission lines of 1 million volts or more. Transformers are then used to convert the high voltage lines to the 120V electrical power used in most homes and businesses.



What is Frequency?

Refers to the frequency of oscillations of alternating current (AC) in an electric power grid transmitted from a power plant to the end-user. Typically for AC power lines, the power frequency is either 60 Hz (primarily North America) or 50 Hz (primarily Europe and other countries around the world).

Fundamentals

What is Hertz?

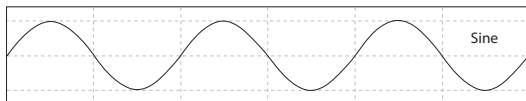
Hertz is the international standard of measurement for frequency in cycles per second.

What is a Cycle?

A series of events that are regularly repeated in the same order. When referring to electricity, it is the transition of voltage or current from a starting point of zero to the positive peak, back through the zero to the negative peak, and returning to zero.

What is a Sine Wave?

A mathematical function that describes a smooth repetitive oscillation. AC electricity alternates current direction based on a 60Hz sine wave in the USA.



What is a Transformer?

An electrical device used to transfer an alternating current or voltage from one electric circuit to another by means of electromagnetic induction. The simplest type of transformer consists of two coils of wire, electrically insulated from one another and arranged so that a change in the current in one coil (the primary) will produce a change in voltage in the other (the secondary).

Fundamentals

What is a Transistor?

A semiconductor device used to amplify and switch electronic signals and current. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current flowing through another pair of terminals. Consider a dimming light switch where it is able to be on, off or at some point in between.



What is Shielding?

The process of applying a conducting barrier between a potentially disturbing noise source and electronic circuitry. Shielding is used to protect cables (data and power) and electronic circuits. Shielding may be accomplished by the use of metal barriers, enclosures or wrappings around source circuits and receiving circuits.

What is Polarity?

Polarity (Positive and negative) is present in every electrical circuit, with Electrons flowing from the negative pole to the positive pole. In a direct current (DC) circuit, one pole is always negative, the other pole is always positive and the electrons flow in one direction only. In an alternating current (AC) circuit, the two poles alternate between negative and positive and the direction of the electron flow reverses.

Fundamentals

What is Grounding?

Generally used to describe the common connection in an electrical or electronic circuit (almost always ultimately routed to the earth). In North America, the standard color for ground is GREEN.

Sensitive electronic systems must be solidly grounded, i.e., directly connected with earth as required by either the ANSI/NFPA-70 or ANSA/NFPA-78, or both. Grounding systems designed for a sensitive electronic equipment facility can be conceptualized as having distinct, solidly interconnected functional subsystems.

The following diagram is an example of a grounding method for a standard enclosure. The grounding method for a particular site also depends on soil type, available space, local codes, National Electric Code requirements and other site-specific characteristics.

Why is Grounding important?

Grounding reduces the risk of serious electric shock from current leaking into uninsulated metal parts of an appliance, power tool or other electrical device. Grounding provides an alternate low potential path for the energy in a circuit to flow.

What is a “Disconnect?”

A device used for control, circuit protection or safety that removes a circuit from a source of power. It takes an electrical device out of action by detaching it from a power supply through the operation of a disconnecting switch, circuit breaker or other switching device.

Fundamentals

What is Bonding?

Electrically connecting all exposed metallic, non-current carrying items in a room or building as protection from electric shock.

What is a Surge?

A transient variation of current, voltage, or power flow in an electric circuit or across an electric system. Surges are typically caused by lightning strikes, power outages, tripped circuit breakers, short circuits, etc.

What is Real, Reactive and Apparent Power?

Real power is the portion of electricity that supplies energy to the load. Reactive power is the portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment (must be supplied to most types of magnetic equipment, such as motors and transformers). Apparent power is the product of the voltage (volts) and the current (amperes), comprised of both active power and reactive power.

$$P = \text{real power} \quad P = I^2R \quad P = \frac{E^2}{R}$$

Measured in units of **Watts**

$$Q = \text{reactive power} \quad Q = I^2X \quad Q = \frac{E^2}{X}$$

Measured in units of **Volt-Amps-Reactive (VAR)**

$$S = \text{apparent power} \quad S = I^2Z \quad S = \frac{E^2}{X} \quad S = IE$$

Measured in units of **Volt-Amps**

Fundamentals

What is Volt Ampere (VA)?

A measure of electrical power. In a DC circuit, one volt-ampere is equivalent to one watt. In an AC circuit, power and VA mean the same thing only when there is no reactance. Reactance is introduced when an electrical circuit contains an inductor or capacitor. Because most AC circuits contain reactance, VA is greater than the actual power delivered in watts.

What is Power Factor?

The relationship of actual power to apparent power. With regards to uninterruptible power, it is the relationship between watts and volt amps.

Example:

$$\text{Power factor} = \frac{\text{True power}}{\text{Apparent power}}$$

$$\text{Power factor} = \frac{119.365 \text{ W}}{169.256 \text{ VA}}$$

$$\text{Power factor} = 0.705$$

$$\cos 45.152^\circ = 0.705$$

What is Lead/Lag?

Lead/lag describes a situation where one (leading) variable is correlated with the values of another (lagging) variable at later times. In the following case, it refers to the relationship between current and voltage in a circuit where current is leading the voltage and alternately the voltage is lagging the current. When charging a battery (capacitor) where the voltage starts low the battery will draw large amounts of current. Eventually the voltage will rise and the current will diminish.

Fundamentals

What is Distortion (PF)?

Distortion, when referring to electricity, is the deviation from the ideal transfer of power where the reactive element of the circuit is reducing the ratio of real power to apparent power. This can happen at the main frequency of the circuit or at multiples of that frequency (harmonics).

What is Efficiency?

The ratio of output over input. Pertaining to energy, it is the amount of power delivered over the amount of power consumed by a device.

What is the difference between Power Consumption and Power Dissipation?

Power consumption is energy being consumed and used by a device, whereas power dissipation is energy being extracted or “given off” by a device rather than delivered to the load.
Consumption = Dissipation + Delivery

What is a Constant Power Source?

A constant power source maintains a consistent energy level output by modifying the voltage in relation to change in demand.

Fundamentals

What is a Constant Power Load?

A load that demands constant power from a source. If the voltage drops the current will increase to maintain a given power consumption.

What is a Blower Door Test?

A special instrument used to measure air leakage in a building and its ductwork. The equipment is made of a temporary door covering which is installed in an outside doorway and a blower which forces air into or out of the building. The blower door measures leaks in the building and ductwork, and can be used to find the exact location of the major leaks.

Sources of Energy

Sources of Energy

What is Electricity?

The flow of power along a conductor (i.e. a wire). In the USA, electricity is measured in kilowatt hours (kWh).

What is an Electricity Supply Service?

The generation and transmission of electricity.

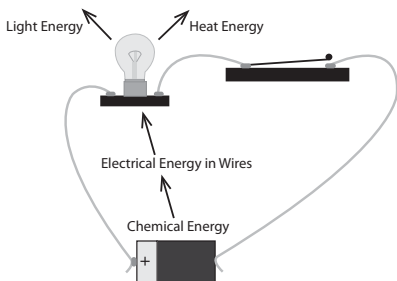
What is a Battery?

One or more electrochemical cells that convert stored chemical energy into electrical energy.

What is Chemical Energy?

The potential of a chemical substance to undergo a transformation through a chemical reaction or to transform other chemical substances, such transformations produce electricity.

Below - Example of Chemical Energy in a Battery



What are Ahrs?

Amp-hours. This is the time-rate measurement of the consumption of current. If a device consumes 1 amp of current for 1 hour, it has consumed 1 Amp-hour (A-hr). This is commonly used to measure the capacity of a battery.

Sources of Energy

What is Battery Capacity?

The amount of electric charge a battery can store.

What are Battery Types?

Pertains to the composition of the battery and how the energy is stored. The three most common types of batteries are Lead-Acid, Lithium-Ion and Nickel Cadmium. Batteries can be further categorized as Flooded (wet), VRLA (Valve-Regulated Lead-Acid) and Gel-cell.

What is a Generator?

A device that converts mechanical energy into electrical energy. Generators can be designed to provide either alternating current (AC) or direct current (DC).

What is a Power Plant?

A central generating facility that creates energy.

What is a Power Supply?

A device that converts power from a source, such as an electricity supply service, battery, generator, or alternative source into a form suitable for use by electronic devices.

What is a UPS? (Uninterruptible Power Supply)

If the AC utility fails, the UPS keeps the system powered without interrupting the load, using batteries to power the device.

Sources of Energy

What is a CableUPS®?

If the AC utility fails, the uninterruptible power supply will keep a cable/broadband system powered without interrupting the load using batteries.



What is Fuel?

A combustible material that can be used to power a generator.

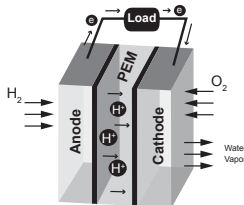
What is Generation/Supply?

Production of electrical energy, generally refers to power plants utilizing fossil fuels or renewables such as solar or wind.

What is a Fuel Cell?

A device capable of generating an electrical current by converting the chemical energy of a fuel (e.g., Hydrogen) directly into electrical energy. Fuel cells differ from generators in that the chemical energy (fuel) is not converted to mechanical energy (through combustion) before being converted into electrical energy.

Figure 1: A typical PEM Fuel Cell



Sources of Energy

Figure 2: Typical Layout of a Fuel Cell Power Plant

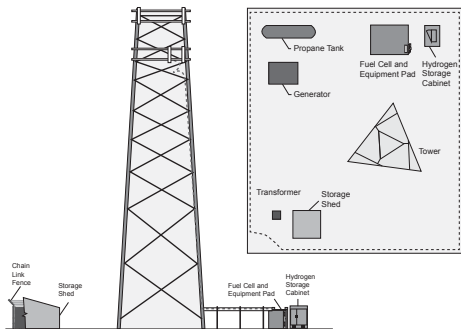


Figure 3: Actual Fuel Cell and Hydrogen Storage Cabinet Installation



What are Renewable Power Sources?

Energy derived from sunlight, wind, falling water, sustainable biomass, energy from waste, municipal solid waste, wave motion, tides and geothermal power, and does not include energy derived from coal, oil, natural gas or nuclear power.

What are Fossil Fuel Sources?

An energy source formed in the Earth's crust from decayed organic material. The common fossil fuels are petroleum, coal and natural gas.

Sources of Energy

What is Wind Power?

The conversion of wind energy into a useful form of electricity. This can be achieved using wind turbines to make electricity, windmills for mechanical power, wind pumps for water pumping or drainage, or sails to propel ships.

What is Daylighting?

Using sunlight instead of electrical lighting.

What is Daylighting Control?

A system that controls electrical lighting in response to variations in available daylight.

What is Photovoltaic Power?

Photovoltaic power is electricity produced using energy derived from the sun's rays.

Photovoltaics uses large silicon panels to capture solar energy, which is then transformed into electricity that can be used to power homes, businesses and potentially entire cities.

What is the Grid?

A system of synchronized power providers and consumers connected by transmission and distribution lines and operated by one or more control centers. Also referred to as the "utility."

What is a Smart Grid?

Delivers electricity from suppliers to consumers using two-way digital technology to control appliances at consumers' homes to save energy and reduce cost.

Sources of Energy

What is a Brownout?

When the voltage on the utility grid is still present but falls below the specified or usable level. The utility can do this in a controlled manner if total power demand surpasses the maximum supply available to curtail a total blackout. The term "brownout" originated from the fact that lights are dimmer during a brownout because there is less power. Long-term exposure to brownouts can damage some types of electrical equipment that depend on a constant power because they will attempt to draw more current to make up for the loss in voltage. Brownouts can also cause unexpected behavior in systems with digital control circuits. Reduced voltages can bring control signals below the threshold at which logic circuits can reliably detect which state is being represented.

2

What is a Blackout?

When power is no longer available from the utility grid. Damaging conditions, like voltage spikes, can occur depending on how the power is interrupted and how the return of power is controlled.

What is Lightning Surge?

This is an introduction of energy into a circuit by a lightning bolt strike on or near a component of that circuit. The strike will cause an increase of both current and voltage within the circuit. If this additional energy is not properly shunted then damage will occur.

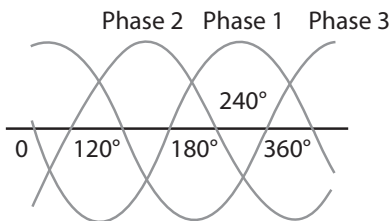
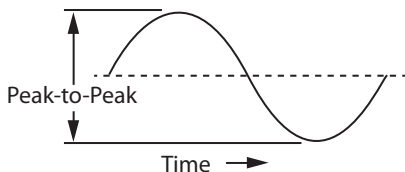
What causes a Power Failure (Blackout)?

Faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system.

Sources of Energy

What is Single-Phase vs. Three-Phase Power?

Single-phase delivers AC power to a circuit over two conductors where both conductors carry the same current equally. A three-phase system uses three conductors where the current supplied between any pair of the three conductors is the same frequency but out of phase (or reaches the peak at a different time) in relation to the other pairs. This provides a current cancellation between the phases allowing higher total currents without the penalty of power loss due the resistance of the conductors. Three-phase is a common method of AC electric power generation, transmission and distribution. A three-phase system is generally more economical than others because it uses less conductor material to transmit electric power than equivalent single-phase or two-phase systems of the same voltage.



Sources of Energy

What is Demand?

The amount of electricity or natural gas delivered to consumers at a point in time.

What is Demand Bid?

Indicates a quantity of energy that a qualified electrical supply service customer is willing to buy.

What is Demand Charge?

The price a consumer pays for its peak usage level.

What is Demand Response?

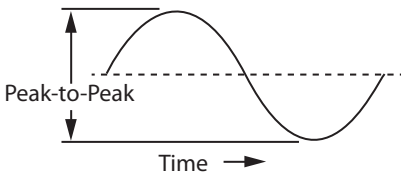
Programs that enable customers to contribute to energy load reductions during times of peak demand.

What is Demand-side Management?

Programs that encourage consumers to modify their level and pattern of electricity usage to generally reduce demand.

What is Peak Demand?

Refers to the time when the demand for electricity is highest.



Sources of Energy

What is Co-generation?

The production of electrical energy and another form of useful energy (such as heat or steam) at the same time.

What is Transmission?

The movement of bulk energy supply from the generation facility to the local distribution company.

Energy Measurement

Energy Measurement

What is a Meter?

A tool for gauging levels or volumes of the measured parameter. An ammeter measures current, a voltmeter measures voltage and a wattmeter indicates power consumption.

What is a Smart Meter?

A type of computerized electrical meter that identifies consumption in more detail than a conventional meter and communicates that information by way of a network back to local utility for monitoring and billing purposes. Also known as advanced metering infrastructure or AMI.

What is a TOU Meter?

A Time-Of-Use (TOU) Meter is a mechanism that measures and reports the times during which a patron uses varying degrees of electricity. This kind of meter is used for patrons who pay time-of-use rates.

What are TOU Rates?

Determining the price of electricity relating to the cost estimates of electricity usage during a specific amount of time. Time-of-use rates are typically separated into several time blocks per twenty-four hour time span (on-peak, off-peak, mid-peak, and sometimes super off-peak) and by seasons. Real-time pricing is different from TOU rates in that it is based on actual (as opposed to predicted) prices which may vary throughout the day and are sensitive to weather, rather than varying with a concrete schedule.

What is an Automatic Meter Reading System?

A structure that records the utilization of electricity, water and gas, and sends the data to a central data gathering mechanism.

Energy Measurement

What is a Meter Rate Multiplier?

A meter that is programmed to document energy at a slower rate relevant to the amount needed. Once the readings are gained, the usage is increased by the programmed rate (multiplier).

What is BTU?

(British Thermal Unit) The quantity of heat required to raise the temperature of 1 pound of liquid water by 1 degree Fahrenheit at the temperature at which water has its greatest density (approx. 39 degrees Fahrenheit).

3

What is a Joule?

A unit of energy equal to the amount of work done when a force of 1 Newton is relocated 1 meter towards the force. It takes 1,055 joules to equal a British Thermal Unit (BTU).

What is a Calorie?

The amount of heat needed to elevate the temperature of 1 gram of water by 1 degree Celsius from a set initial temperature. A calorie is the quantity of heat equal to 4.184 joules.

What is R Value?

The R value is a measure of efficiency of insulation.

What is Electrical Safety?

A set of measures to prevent damage from the uncontrolled transfer of energy. For example, insulating conductors prohibits a person from inadvertently coming in contact with an energized circuit.

Energy Measurement

What is a Lumen?

An empirical measure of the quantity of light. It is based upon the spectral sensitivity of the photosensors in the human eye under high (daytime) light levels.

What is a Ton of Cooling?

A unit used in refrigeration and air conditioning to measure heat absorption.

What is Temperature?

A degree of warmth or coolness measured on one of several scales.

What is a Thermographic Scan?

A diagnostic technique in which an infrared camera is used to measure temperature variations of a subject.

What is a Thermostat?

A device that controls a heating/cooling system to maintain a constant ambient temperature.

What is Thermostat Setback?

A thermostat that can vary the ambient temperature according to a schedule. It reduces overall energy consumption by lessening the utilization of heating and cooling systems when they aren't needed.

What is UA?

Amount of heat that can be transferred through a specified surface or enclosed space (such as a building envelope) with a one degree Fahrenheit temperature difference between the opposing sides. The UA is determined by multiplying the U-value by the area of the surface (or multiple surfaces). UA equals microamperes (one millionth of an ampere).

Energy Measurement

What is the SI Unit Scale?

The modern form of the metric system, it is a system of units of measurement devised around seven base units and the convenience of the number 10.

What are Electrical Formulas?

Mathematical equations used to calculate volts, ohms, amperes, watts, etc.

AC/DC Electrical Formulas			
To Find	Direct Current	Alternating Current	
		Single Phase	Three Phase
Amps when Horsepower is known	$\frac{HP \times 746}{E \times \%Eff}$	$\frac{HP \times 746}{E \times \%Eff \times PF}$	$\frac{HP \times 746}{1.73 \times E \times \%Eff \times PF}$
Amps when Kilowatts are known	$\frac{kW \times 1000}{E}$	$\frac{kW \times 1000}{E \times PF}$	$\frac{kW \times 1000}{1.73 \times E \times PF}$
Amps when kVA is known		$\frac{kVA \times 1000}{E}$	$\frac{kVA \times 1000}{1.73 \times E}$
Kilowatts	$\frac{I \times E}{1000}$	$\frac{I \times E \times PF}{1000}$	$\frac{I \times E \times 1.73 \times PF}{1000}$
Kilovolt-Amps		$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$
Horsepower (output)	$\frac{I \times E \times Eff}{746}$	$\frac{I \times E \times Eff \times PF}{746}$	$\frac{I \times E \times Eff \times 1.73 \times PF}{746}$

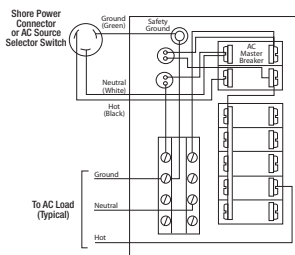
Energy Measurement

Physical Infrastructure

Physical Infrastructure

What is a Circuit Breaker?

A device designed to open and close a circuit manually, and to open the circuit automatically on a predetermined overload of current, without injury to itself when properly applied within its rating. Thus it allows or prevents the flow of electric current whenever current overload or short circuit occurs. Circuit breakers are rated according to amperage and come in various shapes and sizes. Most AC outlets in your home are protected by a 15Amp circuit breaker, whereas the dryer is a 40Amp breaker.



What is a Fuse?

An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of the overcurrent through it. A fuse is used to protect an electrical device from a current surge. The most common fuses are made of glass with a thin piece of wire in the middle. When an overcurrent condition occurs, the wire melts and opens the circuit, interrupting the flow of current.

What is a Trip Curve?

(Time-Current Curves) Used to show how fast a breaker will trip at any magnitude of current.

Physical Infrastructure

What is a “Main”?

A set of conductors (or “line”) extending from the service switch to the main distribution center.

What is a Service Entrance?

Refers to the point where electricity enters an enclosure or dwelling.

What is a Branch Circuit?

A portion of a wiring system in the interior of a structure that extends from a final overload protective device to a plug receptacle or a load such as a lighting fixture, motor, or heater.

What is a Transient Surge Suppressor?

An appliance designed to protect electrical devices from voltage spikes.

4

What is MOV?

(Metal Oxide Varistor) An insulated voltage-dependent resistor. An MOV is a nonlinear resistor whose value varies with the voltage applied across it. The resistance curve has a sharp “knee” in relation to the voltage where the resistance will drop significantly. This is useful to clamp a voltage across a circuit by shunting the energy when a preset voltage is exceeded.

What is Conduit?

An electrical piping system used for protection and routing of electrical wiring.



What is Neutral?

The point along an insulated winding where the voltage is the instantaneous average of the line terminal voltages during normal operation. The term “neutral” is understood to be the center tap of a grounded three-phase transformer winding.

Physical Infrastructure

What is Ventilation?

The process of providing or taking away available air from any area. The air may or may not have been previously treated.

What is HVAC?

(Heating Ventilation and Air Conditioning) A system that supplies heating, ventilation and/or cooling within or connected with a building.

What is a VAV System?

(Variable Air Volume System) A mechanical HVAC System responsible for serving multiple zones by regulating the quantity of warm or cooled air supplied to the zone.

What is an Air Conditioner?

Equipment for air treatment used for air circulation, air cleaning, ventilation and heat transfer. Units usually contain a cooling coil or evaporator and a combination of an electrically-driven compressor and condenser.

What is Heating Seasonal Performance Factor?

A depiction of the entire heating output of a central air-conditioning heat pump in BTU's during its regular usage time for heating, separated by the summation of electrical energy input in watt hours during the same time period.

What is Recool?

The cooling of air that has been formerly heated by HVAC mechanisms.

What is a Fan Coil?

Component of a heating, ventilation and air conditioning (HVAC) mechanism that includes a fan plus a heating or cooling coil; used to allocate warm or cool air.

Physical Infrastructure

What is Cable Loss?

The dissipation of energy over a length of conductor carrying current due to inherent resistance. This will result in a lower amplitude of signal or voltage at the load point than at the source.

What are Losses?

A power decrease caused by resistance in a circuit, circuit element or device.

What are the wire components of an AC outlet?

Hot, neutral and grounding.

What is a Charge Controller?

A device that limits the rate at which electric current is added to or drawn from electric batteries.

What is a Ferro Transformer?

Typical non-standby power supplies use ferroresonant transformer technology to provide line conditioning and voltage regulation. The primary and secondary winding of the transformer are physically isolated from each other by a large steel core which significantly reduces the capacitive coupling of spikes and noise to the secondary winding. This provides a regulated, current-limited output with excellent isolation and noise attenuation.

Advantages of Ferro Technology
1. Immunity to lightning strikes
2. Tolerance of overloads
3. Resistance to physical damage

Physical Infrastructure

What is a Transfer Switch?

Responsible for connecting power sensitive loads to one of several possible power sources, ensuring that the transition between the sources is smooth.

What is an Inverter?

A device that converts direct current electricity (DC) to alternating current electricity (AC). An inverter is used to take DC power from a set of rechargeable batteries and invert it into AC power when there is a utility power outage.

What is PFT Air Infiltration Measurement?

(Perfluorocarbon Tracer Gas) Measures changes over time (a few hours to several months) when determining a building's air-infiltration rate. While this test cannot locate exact points of infiltration, it does reveal long-term infiltration problems. It can be used with or instead of the blower door test.

What is a CFL?

Also known as a compact fluorescent light or energy saving light. It is a type of fluorescent lamp and designed to replace the standard incandescent lamp. CFLs use less power and have a longer rated life.

What is Building Envelope?

The physical separator between the interior and exterior environments of a building.

Financial, Codes, Laws & Standards

Financial, Codes, Laws & Standards

How is Electricity Billed?

The household pays the electric utility company directly for use of electricity (such as water heating, space heating, air-conditioning, lighting and operating appliances).

What is Monthly Energy Usage?

The amount of energy a household or business uses per month, expressed in kWh for electricity. Your energy bill may show your monthly energy usage for up to the past 12 months.

What is the LDC?

Local Distribution Company. The public utility regulated by the State Corporation Commission that owns, maintains and operates the distribution lines and the equipment to deliver electricity to homes and businesses.

What is a Municipal Utility?

An electric or natural gas system owned and operated by a local government.

What is a Tariff?

A schedule of rates or charges of a public utility.

What is Demand Billing?

An arrangement in which a customer of an energy utility pays on the basis of an agreed minimum or maximum; measured in kilowatts.

Financial, Codes, Laws & Standards

What is a Rate Schedule?

A value (a multiplier of the quantity of electricity consumed) used to compute consumer's bills.

What is Real-time Pricing?

Electricity pricing that reflects its real-time cost.

What is a Rate Structure?

(Block-rate structure) An electric rates schedule with a provision for charging a different unit cost for various demands for energy.

What are the components that make up energy costs?

Initial capital, rates and costs of continuous operation, fuel and maintenance.

What is an Energy Audit?

A program carried out by a utility company in which an auditor inspects a building and suggests ways energy can be saved.

What is an Upgrade?

Substitute or addition of electrical gear that concludes in higher generation or transmission.

What is Price to Compare?

The price per kWh of electricity supply service, to be used to contrast prices with competitive service providers.

Financial, Codes, Laws & Standards

What are Cooperatives?

Electric cooperatives are private, independent electric utilities, owned by the members they serve.

What organization regulates power laws in the United States?

Federal Energy Regulatory Commission.

Who is the international power standards developer?

International Electrotechnical Commission.

What is Energy Benchmarking?

Energy benchmarking is the process of quantifying energy use a facility's energy use for the purpose of comparing a facilities's energy use to similar facilities in order to assess opportunities for improvement, and quantifying/verifying energy savings.

What is Energy Charge?

Money owed by an electric consumer for kilowatt hours used.

What is Energy Consumption?

The amount of energy used in the form by which it is obtained by the consumer excluding electrical generation and distribution losses.

What are Renewable Energy Tax Credits?

Credits established by the federal and state government to promote growth in the alternative energy industry.

Financial, Codes, Laws & Standards

What is Net-metering?

Net-metering allows electricity that is generated on-site by an electrical supply service customer to be sold to the service at full retail value when local generation exceeds local demand, the excess may flow back to the service.

What is DOE?

(US Department of Energy) The federal department erected by the Department of Energy Organization Act to bring together the main federal energy operations into one cabinet-level department that devises an all-inclusive, equitable national energy policy.

What is the EPA?

(Environmental Protection Agency) A federal agency created in 1970 to authorize organized governmental action to preserve the environment by systematic reduction and control of pollution through or research, monitoring, setting standards and activities of enforcement.

What is LEED?

(Leadership in Energy and Environmental Design) Consists of a suite of rating systems for the design, construction and operation of high performance green buildings, homes and neighborhoods.

Financial, Codes, Laws & Standards

What are Energy Laws, Codes and Standards?

Energy laws, codes and standards provide baseline requirements and/or guidelines regarding all things energy in an effort to encourage safe energy practices, reduce emissions and contribute to increased sustainability by saving energy and protecting the environment.

What is the Law of Conservation of Energy?

States that energy may neither be created nor destroyed. Therefore the total amount of energy in an isolated system remains constant over time.

What are the types of AC plugs according to National Electric Manufactures Association (NEMA)?

NEMA 1 (two prongs), NEMA 5 (three prongs).



What are Plug Standards (IEC)?

(International Electrotechnical Commission) A set of standards specifying non-locking electrical power couplers for the connection of power supply cords to electrical appliances up to 250 V.

Financial, Codes, Laws & Standards

What is Power Sustainability?

The ability of a power source to provide long-lasting energy.

What is NEC?

The National Electric Code (NEC) consists of electrical safety standards that set the ground rules for practical safeguarding of persons during the installation, operation or maintenance of electric supply and communication lines and associated equipment.



General Reference Information

General Reference Information

Power Conversion Factors

Multiply		By	To Obtain
Power			
Ampere-Hours	x	3600	Coulombs
Btu Per Hour	x	0.293	Watts
Horsepower	x	33000	Foot-Pounds Per Minute
Horsepower	x	550	Foot-Pounds Per Second
Horsepower	x	0.7457	Kilowatt
Horsepower	x	746	Watts
Kilowatts	x	1.341	Horsepower

Multiply		By	To Obtain
Plane Angle			
Degrees	x	0.0175	Radians
Minutes	x	0.01667	Degrees
Minutes	x	2.9×10^{-4}	Radians
Quadrants	x	90	Degrees
Quadrants	x	1.5708	Radians
Radians	x	57.3	Degrees

General Reference Information

Symbols for Power Systems and Facilities

Outlets	
○	Outlet
Ⓓ	Drop Cord
Ⓕ	Fan Outlet
Ⓙ	Junction Box
Ⓛ	Lamp Holder
Ⓢ	Pull Switch
Ⓥ	Vapor Discharge Switch
Ⓧ	Exit Outlet
Ⓒ	Clock Outlet
Ⓑ	Blanked Outlet

Switches	
S	Single Pole Switch
S ₂	Double Pole Switch
S ₃	Three Way Switch
S ₄	Four Way Switch
S _D	Automatic Door Switch
S _E	Electrolier Switch
S _K	Key Operated Switch
S _P	Switch and Pilot Lamp
S _{CB}	Circuit Breaker
S _{WCB}	Weatherproof Circuit Breaker
S _{MC}	Momentary Contacts Switch
S _{RC}	Remote Control Switch
S _{WP}	Weatherproof Switch
S _F	Fused Switch
S _{WPF}	Weatherproof Fused Switch

General Reference Information

Conversion Factors

Multiply		By	To Obtain
Length			
Centimeters	x	0.3937	Inches
Feet	x	12	Inches
Feet	x	0.3048	Meters
Inches	x	2.24	Centimeters
Inches	x	25.4	Millimeters
Kilometers	x	0.6214	Miles
Meters	x	3.281	Feet
Meters	x	39.37	Inches
Meters	x	1.094	Yards
Miles	x	5280	Feet
Miles	x	1.609	Kilometers
Millimeters	x	0.03937	Inches
Yards	x	0.9144	Meters

Multiply		By	To Obtain
Area			
Circular Mils	x	7.854×10^{-7}	Square Inches
Circular Mils	x	0.7854	Square Mils
Square Centimeters	x	0.155	Square Inches
Square Feet	x	144	Square Inches
Square Feet	x	0.0929	Square Meters
Square Inches	x	6.452	Square Centimeters
Square Meters	x	10.764	Square Feet
Square Meters	x	1.196	Square Yards
Square Millimeters	x	0.00155	Square Inches
Square Mils	x	1.273	Circular Mils
Square Yards	x	0.8361	Square Meters

General Reference Information

Multiply		By	To Obtain
Volume			
Cubic Centimeters	x	0.061	Cubic Inches
Cubic Feet	x	0.0283	Cubic Meters
Cubic Feet	x	7.481	Gallons
Cubic Inches	x	0.5541	Ounces
Cubic Meters	x	35.31	Cubic Feet
Cubic Meters	x	1.308	Cubic Yards
Cubic Meters	x	264.2	Gallons
Gallons	x	0.1337	Cubic Meters
Gallons	x	3.785	Liters
Liters	x	0.2642	Gallons
Liters	x	1.057	Quarts
Ounces (fluid)	x	1.805	Cubic Inches
Ounces (liquid)	x	0.9463	Liters

Multiply		By	To Obtain
Force and Weight			
Grams	x	0.0353	Ounces
Kilograms	x	2.205	Pounds
Kilograms	x	0.0011	Tons (short)
Newtons	x	0.2248	Pounds (force)
Ounces	x	28.35	Grams
Pounds	x	453.6	Grams
Pounds (force)	x	4.448	Newtons
Tons (short)	x	907.2	Kilograms
Tons (short)	x	2000	Pounds

General Reference Information

Multiply		By	To Obtain
Pressure			
Atmosphere	x	101325	Pascals
Atmosphere	x	14.7	Pounds Per Square Inch
Pascals	x	0.102	Kilograms Per Square Meter

Multiply		By	To Obtain
Torque			
Gram-Centimeters	x	0.0139	Ounce-Inches
Kilograms-Meters	x	7.233	Pound-Feet
Newton-Meters	x	0.7376	Pound-Feet
Newton-Meters	x	8.851	Pound-Inches
Ounce-Inches	x	72	Gram-Centimeters
Pound-Feet	x	1.3558	Newton-Meters
Pound-Inches	x	0.113	Newton-Meters

Multiply		By	To Obtain
Energy/Work			
Btu	x	778.2	Foot-Pounds
Btu	x	252	Gram-Calories
Btu	x	3.93015×10^{-4}	Horsepower-Hour
Btu	x	1055.056	Joule
Btu	x	2.9309×10^{-4}	Kilowatt-Hour
Coulombs	x	1.036×10^{-5}	Farads
Farads	x	96,500	Amperes
Joule	x	9.478×10^{-4}	Btu
Kilowatt Hour	x	3.6×10^6	Joule

General Reference Information

Celsius to Fahrenheit Conversions

°C	°F	°C	°F	°C	°F	°C	°F
-250	-418	0	32	36	96.8	200	392
-200	-328	1	33.8	37	98.6	225	437
-150	-238	2	35.6	38	100.4	250	482
-100	-148	3	37.4	39	102.2	275	509
-90	-130	4	39.2	40	104	300	572
-80	-112	5	41	41	105.8	325	617
-70	-94	6	42.8	42	107.6	350	662
-60	-76	7	44.6	43	109.4	375	707
-50	-58	8	46.4	44	111.2	400	752
-40	-40	9	48.2	45	113	450	842
-30	-22	10	50	46	114.8	500	932
-25	-13	11	51.8	47	116.6	550	1022
-24	-11.2	12	53.6	48	118.4	600	1112
-23	-9.4	13	55.4	49	120.2	650	1202
-22	-7.6	14	57.2	50	122	700	1292
-21	-5.8	15	59	51	123.8	800	1472
-20	-4	16	60.8	52	125.6	900	1652
-19	-2.2	17	62.6	53	127.4	1000	1832
-18	-0.4	18	64.4	54	129.2	1500	2732
-17	1.4	19	66.2	55	131	2000	3632
-16	3.2	20	68	56	132.2	2500	4532
-15	5	21	69.8	57	134.6	3000	5432
-14	6.8	22	71.6	58	136.4	3500	6332
-13	8.6	23	73.4	59	138.2	4000	7232
-12	10.4	24	75.2	60	140	4500	8132
-11	12.2	25	77	70	158	5000	9032
-10	14	26	78.8	80	176	5500	9932
-9	15.8	27	80.6	90	194	6000	10832
-8	17.6	28	82.4	100	212	6500	11732
-7	19.4	29	84.2	110	230	7000	12632
-6	21.2	30	86	120	248	7500	13532
-5	23	31	87.8	130	266	8000	14432
-4	24.8	32	89.6	140	284	8500	15332
-3	26.6	33	91.4	150	302	9000	16232
-2	28.4	34	93.2	160	320	9500	17132
-1	30.2	35	95	180	356	10000	18032

Temp. C° = 5/9 x (Temp. F° - 32)

Temp. F° = (9/5 x Temp. C°) + 32

Ambient Temperature is the temperature of the surrounding cooling medium.

Rated temperature rise is the permissible rise in temperature above ambient when operating under load.

General Reference Information

U.S. Weights and Measurements

Linear Measure				
		1 Inch	Equals	2.54 Centimeters
12 Inches	Equals	1 Foot		3.046 Decimeters
3 Feet		1 Yard		9.144 Decimeters
5280 Feet		1 Mile		1.609 Kilometers

Area Measure		
1 Sq. Foot	Equals	144 Sq. Inches
1 Sq. Yard		9 Sq. Feet
1 Acre		4 Roods
1 Sq. Mile		640 Acres
1 Section		1 Sq. Mile

General Reference Information

Weight Measurements		
Avoirdupois Weight System		
1 Ounce	Equals	16 Drams
1 Pound		16 Ounces
1 Hundredweight		100 Pounds
1 Ton		2000 Pounds
Troy Weight System		
1 Carat	Equals	3.17 Grains
1 Pennyweight		20 Grains
1 Ounce		20 Pennyweights
1 Pound		12 Ounces
Kitchen Weight System		
1 U.S. Pint	Equals	16 Fl. Ounces
1 Standard Cup		8 Fl. Ounces
1 Tablespoon		0.5 Fl. Ounces
1 Teaspoon		0.16 Fl. Ounces

Liquid Measurements		
1 Pint	Equals	2 Cups
1 Quart		2 Pints
1 Gallon		4 Quarts
1 Barrel		42 Gallons (petroleum or crude oil)

General Reference Information

Cubic Measurements		
1 Cu. Foot	Equals	1728 Cu. Inches
1 Cu. Yard		27 Cu. Feet
A Cu. Foot		7.48 Gallons
1 Gallon (water)		8.34 lbs
1 Gallon (U.S.)		231 Cu. Inches of water

Metric System

Linear Measure				
1 Centimeter	Equals	10 Millimeters	Equals	.39 Inches
1 Decimeter		10 Centimeters		3.94 Inches
1 Meter		10 Decimeters		39.37 Inches
1 Dekameter		10 Meters		32.8 Feet
1 Hectometer		10 Dekameters		328.08 Feet
1 Kilometer		10 Hectometers		3280.8 Feet

General Reference Information

Area Measure				
1 Sq. Centimeter	Equals	100 Sq. Millimeters	Equals	.155 Sq. Inches
1 Sq. Decimeter		100 Sq. Centimeters		15.5 Sq. Inches
1 Sq. Meter		100 Sq. Decimeters		10.76 Sq. Inches
1 Sq. Dekameter		100 Sq. Meters		1076.4 Sq. Feet
1 Hectare (ha)		100 Sq. Dekameters		2.47 Acres
1 Sq. Kilometer		100 Sq. Hectometers		.386 Sq. Miles

Weight Measurements				
1 Centigram	Equals	10 Milligrams	Equals	.15 Grains
1 Decigram		10 Centigrams		1.54 Grains
1 Gram		10 Decigrams		.035 Ounces
1 Dekagram		10 Grams		.35 Ounces
1 Hectogram		10 Dekagrams		3.52 Ounces
1 Kilogram		10 Hectograms		2.2 Pounds
1 Quintal		100 Kilograms		220.46 Pounds
1 Metric Ton		10 Quintals		1.1 Short Tons

General Reference Information

Liquid Measurements				
1 Centiliter	Equals	10 Millimeters	Equals	.34 Fl. Ounces
1 Deciliter		10 Centiliters		3.38 Fl. Ounces
1 Liter		10 Deciliters		33.81 Fl. Ounces
1 Dekaliter		10 Liters		2.64 Gallons
1 Hectoliter		10 Dekaliters		26.42 Gallons
1 Kiloliter		10 Hectoliters		264.18 Gallons

Cubic Measurements				
1 Cu. Centimeter	Equals	1000 Cu. Millimeters	Equals	.06 Cu. Inches
1 Cu. Decimeter		1000 Cu. Centimeters		61.02 Cu. Inches
1 Cu. Meter		1000 Cu. Decimeters		35.31 Cu. Feet

General Reference Information

Measurement of Fuels

Unit Type	Fuel Type	Fuel Units	Unit Symbol
AC Generator	Natural Gas	Cubic Feet	cf
AC Generator	Diesel	Gallons	gal
DC Generator	Natural Gas	Cubic Feet	cf
DC Generator	LP - Liquid Petroleum	Gallons	gal
Fuel Cell	Hydrogen	Pounds	lbs.

General Reference Information

Metal Properties

Metal or Alloy	Specific Gravity (g/cc)	Melting Point		Thermal Cond. 20°C W/CM. °C	Thermal Expansion Near 20°C (X 10 ⁻⁴ /°C)	Electric Cond. % Copper
		°F	°C			
Aluminum (Al)	2.70	1120	660	2.22	23.6	.0978
Beryllium (Be)	1.83	2354	1280	1.46	11.6	.0660
Bismuth (Bi)	9.80	520	271	0.08	13.3	.3540
Brass	8.51	1652	900	1.17	20.3	.3070
Bronze	8.87	1832	1000	1.88	18.4	.3200
Cadmium (Ca)	8.65	610	321	0.92	29.8	.3120
Cobalt (Co)	8.90	2723	1495	0.69	13.8	.3210
Copper (Cu)	8.89	1981	1083	3.91	16.8	.3210
Gold (Au)	19.30	1945	1063	2.96	14.2	.6970
Iron (Fe)	7.2	2800	1538	0.75	11.8	.2600
Lead (Pb)	11.40	621	327	0.35	29.3	.4120
Magnesium (Mg)	1.74	651	1204	1.53	27.1	.0628
Mercury (Hg)	13.65	-37.7	-38.9	0.08	-	.4930
Molybdenum (Mo)	10.20	4730	2610	1.42	4.9	.3680
Monel	8.87	2372	1300	0.26	14.0	.3200
Nickel (Ni)	8.90	2647	1453	0.61	13.3	.3210
Platinum (Pt)	21.46	3221	1773	0.69	8.9	.7750
Silver (Ag)	10.50	1760	960	4.18	19.7	.3790
Steel	7.84	2436	1330	0.5	11.0	.2830
Tin (Sn)	7.30	450	232	0.63	23.0	.264
Titanium (Ti)	4.50	3034	1668	0.41	8.4	.162
Tungsten (W)	19.30	6170	3410	1.67	4.6	.697
Uranium (U)	18.70	2066	1130	0.27	7-14	.675
Zinc (Zn)	7.14	788	420	1.10	33.0	.258
Zirconium (Zr)	6.40	3366	1852	0.21	0.58	.231



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