Battery Requirements

Support - Safety

A lead acid motive power battery can be an extremely useful, safe, source of electrical power. On the other hand, if improperly used, it can be an extremely dangerous piece of equipment. The difference between the two conditions is determined by the care and safety procedures exercised in handling batteries. Before considering the safety procedures, first consider the hazards inherent to a lead- acid battery.

The Hazards

A lead - acid battery, by its very construction, exposes working personnel to four potentially dangerous elements: sulfuric acid, explosive gases, electricity and heavy weight.
A sulfuric acid solution is used as the electrolyte in lead - acid storage batteries and has a concentration of approximately 40% by weight of sulfuric acid in water. Even in this diluted state, sulfuric acid is a strong oxidizing agent and can burn the skin and eyes and "eat" holes in clothes made of many common materials.

An explosive mixture of oxygen and hydrogen is produced in a lead - acid storage battery during the charging process. The two gases can combine explosively if a spark or flame ignite them. Because hydrogen is so light, it normally floats away and disperses into the air before it can collect into an explosive mixture. However, if it accumulates into gas pockets, it will explode when ignited.

Electricity is produced by the battery on discharge and while most persons cannot "feel" voltages through their bodies below 35 or 40 volts, all motive power batteries should be regarded as potentially dangerous. A lead - acid battery is capable of discharging at extremely high rates and under conditions of direct shorting, which can cause much damage and serious injury.

The weight of these heavy batteries can crush hands and feet if care is not taken when charging and handling them. Adequate and proper handling equipment should be provided. The average lift truck battery weighs over 2000 pounds.

The Safety Procedures

In 1970, Congress passed the Occupational Safety and Health Act (OSHA). The act established the minimal acceptance standards of safe and healthful working conditions. The act not only pinpoints the responsibility of employer and employee, but also establishes the penalties for disregarding the standards. It would be well to remember that OSHA standards are minimum requirements. The safety procedures suggested on this website have been compiled by standards developed over the years by professional and technical organizations and by battery manufacturers and users who have had the experience necessary to create the most effective safety standards. They exceed the minimum standards for OSHA for personnel safety and include procedures for safeguarding equipment as well.

Safety Procedures:

1. **ALWAYS** use safety glasses or face shield when working on or near batteries,
2. **NEVER** wear jewelry when working on or near batteries or battery chargers,
3. **ALWAYS** use caution when using tools around batteries,
4. **KEEP** all open flames, sparks, etc. away from batteries and battery charging areas,
5. **ALWAYS** make sure that the charger is off before connecting or disconnecting battery to the charger,
6. **REPORT** any damage or problems immediately so that it can be repaired and not pose any threat to safety.
7. **ALWAYS** use the proper equipment for lifting and changing out batteries,

Note: The information presented is of general nature. It should not be construed as a legal opinion.

Support - Basic Battery Care

- Add water as needed - do not overfill.
- Always keep electrolyte level above separator protectors.
- Keep vent caps tightly in place.
- Charge battery on properly matched charger.
- Allow battery to cool down before placing it back into service.
- Keep battery top clean, dry and free of foreign objects.
- Keep battery and truck cover open during charging.
- Batteries produce explosive gases. Keep flame and sparks away from battery.
- Do not discharge beyond 80% (1.140 -1.160 SP.GR.)
- Report any problems or damage. Minor problems can become major ones.
- Good battery care is not a luxury, it's a necessity!!

Support - Cleaning

To prevent corrosion and the resultant problems, batteries must be cleaned and dries routinely.

Sometimes minor spills or overflows of electrolyte occur due to overfilling. Instead of giving the battery a general cleaning at this time, the moisture can be removed with rags or paper towels. (This should be immediately disposed of.)

The frequency of a general cleaning depends upon two factors:

1. How quickly dust, dirt, oil, and other foreign matter accumulates on the top of the battery, and
2. How quick the electrolyte spillage accumulates.

When the top of a battery is “dirty” or looks damp, it is ready for a general cleaning. It could be as often as every two weeks or as infrequent as every six months, depending on the battery’s environment and the care it receives. The average battery needs general cleaning every three months.

To give a battery a general cleaning, use hot water (130 degrees F. to 170 degrees F.) with a neutralizing detergent solution. The neutralizer / detergent solution is made by mixing ½ pound of baking soda, or ½ pint of household ammonia, with the recommended amount of detergent for general cleaning with one gallon of clear water.

Apply the solution with a clean paint brush to the top of the battery, working it under the intercell connectors and the terminals to loosen the grime and neutralize the acid. If baking soda is in the solution, apply the mixture until the “fizzing” action stops. (An ammonia solution will not ”fizz”.) Then rinse the battery with clean, hot water from a low pressure hose to remove all traces of the solution and loose dirt. Cold water works, but hot water cleans better.

During any cleaning, but particularly when using a neutralizer / detergent solution, make certain that all vent caps are tightly in place.

Support - How to Jump Start a Battery

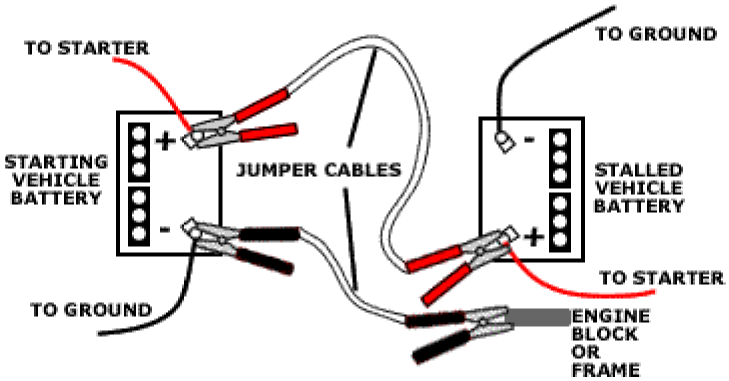
If the battery won't start your car, you usually refer to it as "dead," even though that's not technically correct. A battery that's merely discharged - from leaving your headlights on or from a damaged alternator - can be recharged to its full capacity. But a battery that's at the end of its service life, can't be recharged enough to restore it to a useful power level. Then it truly is dead and must be replaced.

If the battery is discharged, not dead, you can jump-start it from another fully charged battery. About 30 minutes of driving should allow the alternator to charge your battery until you take it to a service station for a full charge. But if the alternator or another part of the electrical system in your car is damaged, they won't be able to recharge your battery. So if your battery keeps discharging, before you replace it, have your electrical system checked. What looks like a bad battery could be an electrical system problem. If you have a bad component in the electrical system, it will keep draining a new battery and you'll be stranded again and again.

Warning : Shield eyes and face from batteries at all times.

Don't jump start a damaged battery. Be sure vent caps are tight and level. Be sure vehicles do not touch and ignitions are off.

1. Connect positive (+) jumper cable to positive (+) terminal of discharged battery.
2. Connect other end of positive (+) cable to positive (+) terminal of assisting battery.
3. Connect negative (-) cable to negative (-) terminal of assisting battery.
4. Make final connection of negative (-) cable to engine block of stalled vehicle, away from battery.
5. Start vehicle and remove cables in reverse order.



Support - Charging

Types of Charging

There are number of different charging methods; although only four need explanation. These are a Freshening Charge, Cycle Charging, Equalizing Charging and a new charging concept, called Opportunity Rapid Charging.

Cycle Charge

Cycle charging is the complete recharging of a battery after it has been fully or partially discharged during normal operations. Typically, a cycle charge is based on an 8-hour time period that recharges the battery and restores it to a fully charged condition.

Equalizing Charge

Each cell in a battery is an individual; each has a slight difference in uniformity in construction and content. The slight differences cause some cells to take less charge then the other cells in the battery. Over a period of time, the state of charge of some cells will require more charge then the other cells. To correct this condition, an equalize charge is given as it extends the charge cycle beyond the normal 8 hour charge period. This is typically for an additional 3 hours, at a very low rate. This allows the weaker cells that drift back in capacity and will limit the battery from delivering its full capacity potential. To bring all the cells back to an equal state of charge, the battery must be given an equalizing charge. An equalizing charge should be given at the end of each workweek. This will allow the battery to become fully charged and provide ample cool down time before the beginning of the next week.

Freshening Charge

A freshening charge is used to bring a new battery to a fully charged condition before it is placed into service, or when a battery has been standing idle for a short time period. A freshening charge is typically a soft charge at a low output (3 to 6 amperes per 100 ampere hours of the battery's rated capacity) for approximately 3 hours. This allows the battery to be restored to a fully charged condition maximizing the battery's electrical storage capability. All new batteries should receive a freshening charge before placing the battery into service.

The Charging Process

When a battery is placed on charge, the opposite action of battery discharge takes place; that is, the sulfate in the active material of the plates in driven back into the electrolyte. This reduces the sulfate in the plates and increases the specific gravity of the electrolyte, an electrochemical process which continues until the on-charge cell voltages reach 2.50 to 2.70 volts per cell, dependent upon the type of charging equipment used.

Finish rate or "normal" rate is that current which can be used safely any time charging is required, and which can be continued after the completion of the charge without causing excessive gassing or high temperature resulting from overcharge. The finish rate is shown on the nameplate of Crown Batteries.

Generally speaking, it is 3.5 amperes per 100 hours of the battery's 6-hour rate capacity. A partially, or completely discharged battery can safely handle currents much higher than the finish rate, but as it approaches full charge, whatever charging rate is used must be reduced to the finish rate. The chart "Typical Recharging Characteristics" shows this finish charging rate. The curves are typical of the recharge of an 18-cell battery, which was discharged 100 ampere hours, and shows specific gravity, current, voltage and cell temperature. Note that after approximately 5 hours of charge, when the battery if about 85% of its nominal full charge, the charging current is reduced sharply to a level which is maintained until charging is complete. Then the battery is fully charged, the current is stopped or should be reduced to a very low rate.

Determining if a Battery is Properly Charged

If the battery charging equipment is functioning properly, and if the battery is in a healthy condition, there is little chance for an improperly charged battery. If some doubt about its operation exists, the following checks are a quick way of determining a proper, fully charged battery.

1. Charging current readings will level off to the finishing rate.
2. Charging voltage stabilizes.
3. No rise in specific gravity.
4. Normal gassing.

Overcharging

An excessive amount of charge results in high battery temperature, reducing the battery's service life.

Overheating

To obtain maximum service life from a battery, it should be charged and operated at temperatures below 115 degrees F. Above this temperature, overheating occurs. Overheating can damage the battery and shorten its normal expected service life. The extent of the damage and service life loss depends on how high the temperature, how often the overheating occurs, and how long the batteries are subjected to high temperatures.

A healthy battery charged on a properly functioning charger will have a 10 to 20 degree F. rise in temperature when fully charged from a completely discharged state. What causes a battery to go beyond this range and overheat? The temperature rise is affected by several variable factors:

1. Age and condition of the battery
2. Battery temperature compared to ambient temperature
3. Start, intermediate and finish rate of the charger
4. The amount of overcharge given the battery

In lift truck operations, a battery can overheat because of the operating requirements of the truck, as well as the operating environment. If a lift truck requires almost continuous current draws that are higher than normal, the temperature will rise. Ideally, for this operation, a "cool" battery whose temperature is 90 degrees F. or lower should be installed in the truck. However, if the lift truck operations starts with an overheated battery whose temperature is above 115 degrees F., the continuous high current draws will tend to make the temperature rise even higher and battery damage is likely.

Typical working environment where batteries must operate in an overheated condition are in a foundry, where ambient temperatures reach 120 degrees F. and higher; and in heavy-duty operations where they must be charged every 5 to 6 hours with no time for cooling before charge. The latter problem can often be alleviated by having more than two batteries per truck. For the former, an inexpensive way to cool the battery is by directing a fan over its intercell connectors and since the conduct 60% of the heat out of the battery, the battery will cool rapidly. Charge with battery covers open. Operating and charging batteries at elevated temperatures is a frequent cause of battery damage and reduced service life. An experienced lift truck batteryman, given the levels of operation and charging temperatures, and time span for which they are held, can estimate the percentage of service life lost. The estimated loss expressed as a percent, can serve as the basis for deciding whether to invest in extra batteries, higher capacity batteries or battery cooling equipment.

Keyed Connectors

Sometimes, batteries of several different voltages and ampere-hour capacities are charged at the same time at the same centralized location. Precautions must be taken to make sure that batteries are charged on chargers with mating voltages and ampere-hour ratings. Rather than rely on the persons placing the batteries on the chargers, we recommend the use of plugs and connectors of different types or the use of keyed and color-coded connectors.

Gassing

When a battery is charging, the electrolytic breakdown of the water in the electrolyte produces oxygen on the positive plates and hydrogen on the negative plates. This is normal. However, if a high charging rate is continued after the battery has been brought to its gassing voltage, the gassing becomes excessive, and abnormally larger amounts of hydrogen and oxygen gases are produced. The best indication of excessive gassing is a very noticeable "bubbling" action of the electrolyte and high electrolyte temperature.

Hydrogen is a highly combustible gas and will explode on ignition when is connection in air reaches any level between 4 percent and 74 percent. (Below 4% the concentration is too weak; above 74% there is not enough oxygen left in the air to support combustion.) If you have reason to suspect excessive gassing, troubleshoot the battery and charging equipment. An unusually high usage of water indicates that excessive gassing is occurring.

Undercharging

Undercharging a battery, even to a small degree, if continued, leads to excessive "sulfation". The same is true of batteries which have been left standing in an undercharged state for an extended period. High temperatures rapidly accelerate sulfation when batteries are left standing in a partially charged condition. The cells of a sulfated battery will give low specific gravity and open circuit voltage readings. On charge, voltage readings will be unusually high. The battery will not become fully charged after a single normal charging when sulfation has taken place over a prolonged period.

Opportunity Rapid Charge

New charger technology has been developed to allow batteries to be charged faster and at substantially higher charge rates, called Opportunity Rapid Charging or Fast Charging.

Opportunity charging is charging the battery at every opportune time possible. The battery should be charged at breaks, lunches, and at the end of each shift and any other times when the battery can be charged for at least 10 minutes. Rapid charging is defined as charging the battery from 20% to 80% state of charge in two hours or less. By opportunity charging the battery the state of charge is maintained between 30% and 80% during the normal work shift. Once a day, the battery is allowed to recharge to 100% of its rated capacity. On weekends, the battery will be automatically equalize charged while it is still connected to the charger. Opportunity Rapid Charging can only be safely accomplished with a specially designed charger with sophisticated control capable of monitoring battery conditions.

Support - Adding Water

Generally, a certain amount of water loss is normal in all batteries, and it should be replaced with "pure" tap water or distilled water. In some areas around the country, tap water may contain chemicals or other impurities harmful to batteries. If water is needed, add just enough to bring the electrolyte to the proper level. Batteries should be filled only at the end of the charging cycle. Overfilling is the most common error made when watering, and it can cause tray corrosion. Because tray corrosion can cause EXTENSIVE DAMAGE to batteries and vehicles, extreme caution must be taken to avoid overfilling the batteries.

Tray Corrosion

Most trays for motive power batteries are made of steel that is protected with an acid resistant coating. Regardless of how good the coating is, if a break in the coating exposes the steel tray to the sulfuric acid spilled from the battery, the acid will corrode the tray. How quickly the tray corrodes depends on how much and how often acid is spilled on top of the battery, and how often the battery is cleaned.

The major cause of tray corrosion if overwatering or overfilling a battery. When overfilled, the electrolyte will spill on top of the battery. Although the water in the electrolyte will evaporate, the highly concentrated acid solution remains and gives the appearance of dampness. If the acid is not removed, the tray will eventually corrode. To prevent corrosion, batteries should be cleaned any time the accumulation of dampness or acid becomes significant.

A good technique to follow in watering batteries is to use a flashlight focused on the vent hole being watered. Visually, watch the level of the electrolyte rise, and stop watering the instant the proper level is reached. Each cell is filled in the same way. Cell filling equipment that automatically fills batteries to the proper level is available.

In addition to causing tray corrosion, the accumulation of acid in conjunction with the corrosion can cause grounds. Two significant grounds can create an external short through the case of the battery. As a result, some or all of the cells continually discharge. And as the current carrying ability of the multiple grounds increases, further complications such as jar leakage, overheating, cell failure, etc., can occur. Furthermore, grounds can also cause serious problems or failures in the electronic controls or electrical components of the vehicle.

To test for a ground in a battery, set the voltmeter to handle the sill open circuit voltage of the battery being tested. Place the positive probe on the positive

terminal of the battery and the negative probe on the spot of the steel tray where bare steel is exposed. Make sure that the negative probe penetrates the paint to the steel. To detect the location of the ground, move the positive probe from intercell to intercell connector until the lowest voltage reading is found. This will be the grounded cell. To clear the ground, clean the top of the battery of acid and corrosion and dry. If the ground is still present, reseal the battery with asphaltic compound.

Watering Schedule

Low electrolyte level in a cell can cause the plates to oxidize and shorten the life of the cell and the battery. To prevent this needless and wasteful damage, water should be added often enough to keep the electrolyte level above the perforated separator protectors. Ideally, a watering policy or schedule should be adopted and followed strictly. One of two systems can be used. In the first, the electrolyte level of two or three cells is checked each time the battery is charged. In the second, water is added to all of the batteries assigned to each charging area on a regular time schedule. The electrolyte levels are also spot checked periodically to determine if the proper levels are being maintained, if the second method is used.

Determining a reasonable and proper battery watering time schedule could be easy or difficult, depending on how widely the following threes factors very:

1. Frequency of charge (daily, 1 ½ times a day, three times a week, etc.).
2. Water storage capacity of the specific cell type.
3. Age and condition of the battery.

Older batteries and those in poor condition will consume water more rapidly than newer batteries and those in good condition. Also some cell types have a greater water storage capacity than others.

Depending on the preceding variable factors, the batteries assigned to a specific charging area will require watering at different intervals. The frequency of watering is best determined by first-hand experience. Example: If some batteries have low electrolyte levels when a weekly watering schedule is followed, change the schedule to twice a week.

Support - Battery Terms

Active Material - The active material in the positive plates is lead dioxide and active material in the negative plates is metallic sponge lead. When an electrical circuit is created, these materials react with sulfuric acid during charging and discharging according to the following chemical reaction:
$PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O$

Ampere (Amp. A.) - The unit of measure of the electron flow rate, or current, through a circuit.

Ampere-Hour (Amp.-Hr, AH) - A unit of measure for a battery's electrical storage capacity, obtained by multiplying the current in amperes by the time in hours of discharge. (Example: A battery which delivers 5 amperes for 20 hours delivers 5 amperes X 20 hours = 100 Amp.-Hr of capacity.)

Capacity - The ability of a fully charged battery to deliver a specified quantity of electricity (Amp-Hr, AH), at a given rate (Amp, A), over a definite period of time (Hr). The capacity of a battery depends upon a number of factors such as: active material weight, density of the active material, adhesion of the active material to the grid, number, design and dimensions of plates, plate spacing, design of separators, specific gravity and quantity of available electrolyte, grid alloys, final limiting voltage, discharge rate, temperature, internal and external resistance, age and life history of the battery.

Cell - The basic electrochemical current-producing unit in a battery, consisting of a set of positive plates, negative plates, electrolyte, separators and casing. There are six cells in a 12 volt battery.

Circuit (Series) - A circuit which has only one path for the flow of current. Batteries arranged in series are connected with negative of the first to positive of the second, negative of the second to positive of the third, etc. If two 12-volt batteries of 50 ampere-hours capacity each are connected in series, the circuit voltage is equal to the sum of the two battery voltages, or 24 volts and the ampere-hour capacity of the combination is 50 ampere-hours

Circuit (Parallel) - A circuit which provides more than one path for the flow of current. A parallel arrangement of batteries (usually of like voltages and capacities) has all positive terminals connected to a conductor and all negative terminals connected to another conductor. If two 12 volt batteries of 50 ampere-hour capacity each are connected in parallel, the circuit voltage is 12 volts, and the ampere-hour capacity of the combination is 100 ampere-hours.

Cold Crank Rating - The number of amperes a lead acid battery at **0°F (-17.8°C**) can deliver for 30 seconds and maintain at least 1.2 volts per cell.

Corrosion - The destructive chemical reaction of a liquid electrolyte with a reactive material - e.g. dilute sulfuric acid on iron, producing corrosion products such as rust. Battery terminals are subject to corrosion if they are not properly maintained.

Cranking Performance (sometimes referred to as Marine Cranking Amps or MCAs) - The number of amperes a lead-acid battery at **32°F (0°C)** can deliver for 30 seconds and maintain at least 1.2 volts per cell.

Current - The rate of flow of electricity, or the movement of electrons along a conductor. It is comparable to the flow of a stream of water. The unit of measure for current is the ampere.

Current (Alternating)(AC) - A current that varies periodically in magnitude and direction. A battery does not deliver alternating current (AC).

Current (Direct)(DC) - An electrical current flowing in an electrical circuit in one direction only. A battery delivers direct current (DC) and must be recharged with direct current in the opposite direction of discharge.

Cycle - In a battery, one discharge plus one recharge equals one cycle.

Discharging - When a battery is delivering current, it is said to be discharging.

Electrolyte - In a lead-acid battery, the electrolyte is sulfuric acid diluted with water. It is a conductor that supplies water and sulfate for the electrochemical reaction:
$PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O$

Element - In a battery, a set of positive and negative plates assembled with separators.

Forming - In battery manufacturing, formation is the process of charging the battery for the first time. Electrochemically, formation changes the lead oxide paste on the positive grids into lead dioxide and the lead dioxide paste on the negative grids to metallic sponge lead.

Grid - A lead alloy framework that supports the active material of a battery plate and conducts current.

Ground - The reference potential of a circuit. In automotive use, the result of attaching one battery cable to the body or frame of a vehicle which is used as a path for completing a circuit in lieu of a direct wire from a component. Today, over 99% of automotive and LTV applications use the negative terminal of the battery as the ground.

Hydrometer - A float type device used to determine the state of charge of a battery by measuring the specific gravity of the electrolyte (i.e. the concentration of sulfuric acid in the electrolyte).

Load Tester - An instrument which draws current (discharges) from a battery using an electrical load while measuring voltage. It determines the battery's ability to perform under actual discharge conditions.

Low Water Loss Battery - A battery which does not require periodic water addition under normal driving conditions; also referred to as a maintance-free battery.

Negative - Designating, or pertaining to, electrical potential. The negative battery terminal is the point from which electrons flow during discharge.

OHM - A unit for measuring electrical resistance or impedance within an electrical circuit.

OHM's Law - Expresses the relationship between volts (V) and amperes (I) in an electrical circuit with resistance (R). It can be expressed as follows: **V = IR**
Volts(V) = Amperes(I) x Ohms(R). If any two of the three values are known, the third value can be calculated using the above equation.

Open Circuit Voltage - The voltage of a battery when it is not delivering or receiving power. It is 2.11 volts for a fully charged battery cell, or 12.66 for a fully charged 12 volt battery. (6.33 for a 6 volt battery)

Positive - Designating or pertaining to, a kind of electrical potential; opposite or negative. A point or terminal on a battery having lower relative potential.

Primary Battery - This type of battery can store and deliver electrical energy but cannot be recharged.

Reserve Capacity Rating - The time in minutes that a new, fully charged battery will deliver 25 amperes at **80°F** and maintain a terminal voltage equal to, or higher than, 1.75 volts per cell. This rating represents the time the battery will continue to operate essential accessories if the alternator or generator of a vehicle fails.

Resistance (Electrical) - The opposition to the free flow of current in a circuit. It is commonly measured in Ohms

Secondary Battery - A battery which can store and deliver electrical energy and can be recharged by passing direct current through it in a direction opposite to that of discharge.

Separator - A divider between the positive and negative plates of an element which allows the flow of current to pass through it. Separators are made from numerous materials such as: polyethylene, polyvinyl chloride, rubber, glass fiber, cellulose, etc

Short Circuit - An unintended current bypass in an electric device or wiring, generally very low in resistance and thus causing a large current to flow. In a battery, a cell short circuit may be permanent enough to discharge the cell and render the battery useless.

Specific Gravity (Sp. Gr.) - The density of a liquid compared to the density of water. The specific gravity of the electrolyte is the weight of the electrolyte compared to the weight of an equal volume of pure water.

State of Charge - The amount of electrical energy stored in a battery at a given time expressed as a percentage of the battery when fully charged.

Volt - The unit of measure for electrical potential.

Voltage Drop - The net difference in the electrical potential (voltage) when measured across resistance or impedance (Ohms). Its relationship to current is described in Ohm's law.

Watt - The unit for measuring electrical power i.e., the rate of doing work, in moving electrons by, or against, an electrical potential. Formula: **Watts = Amperes x Volts**

Watt-Hour (Watt-Hr, WH) - The unit of measure for electrical energy expressed as Watts x Hours.