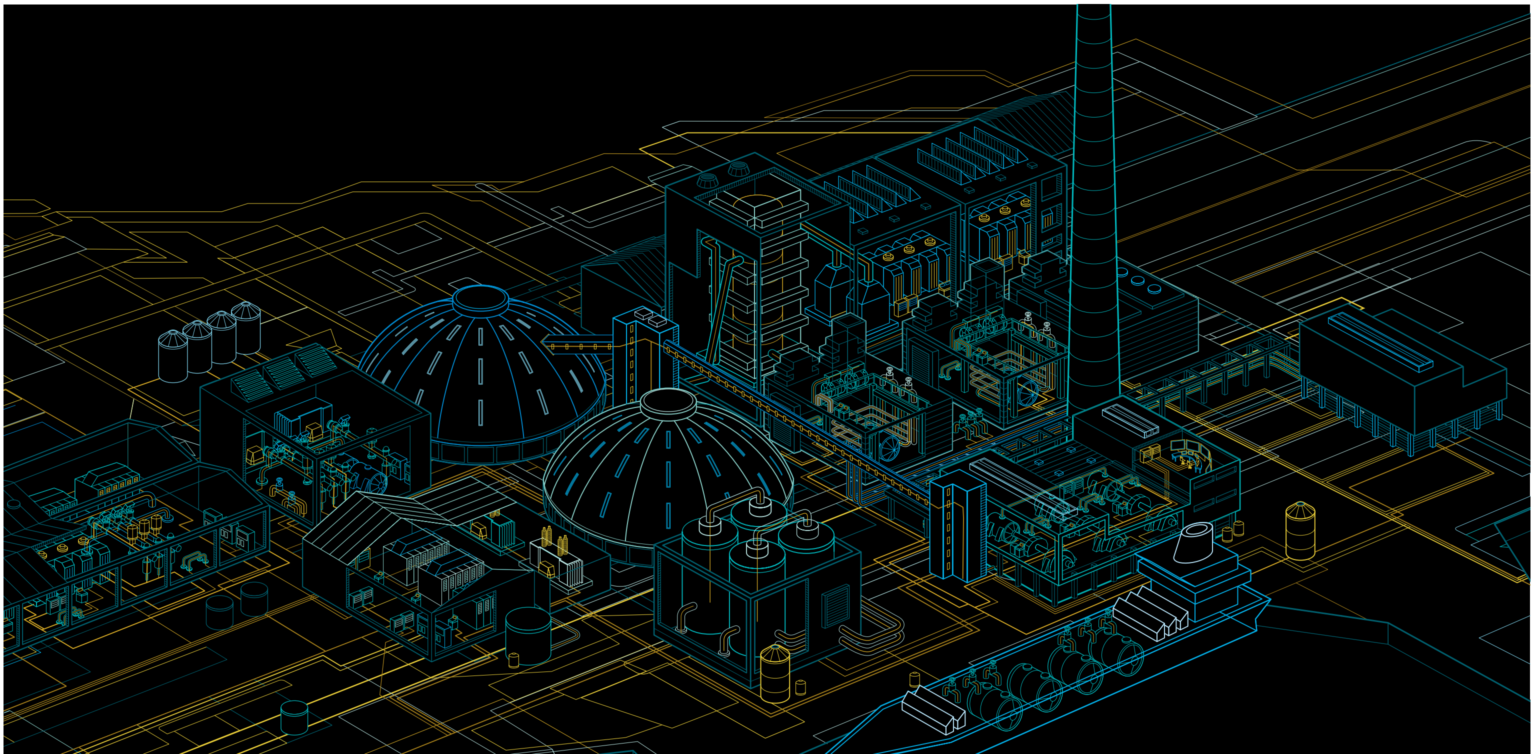

Product brochure

Cyberex® Industrial UPS FAQs

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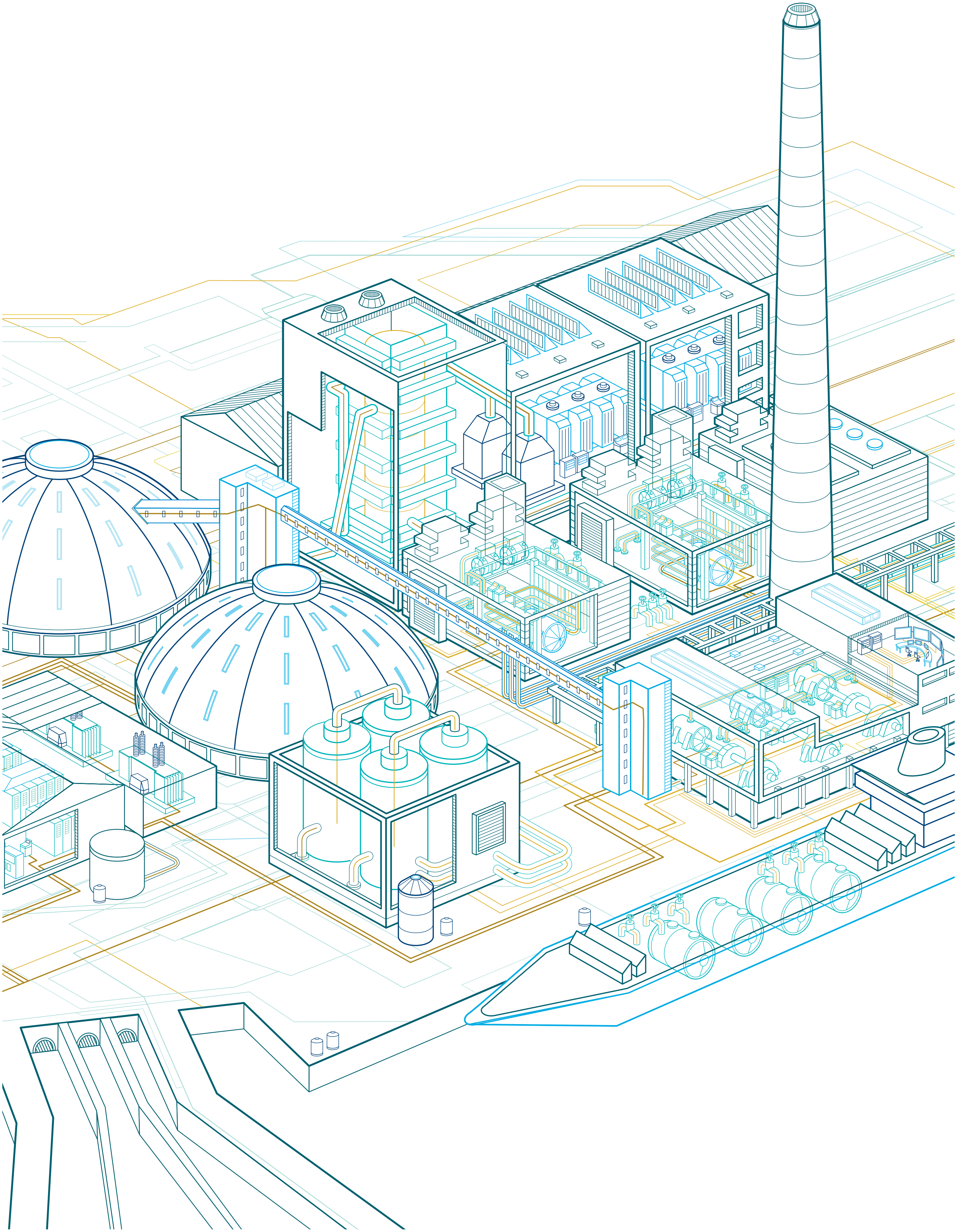

Industrial UPS – FAQs

What is a UPS?

A UPS is an electrical device that provides continuous, conditioned, uninterrupted power to a critical AC load. It also provides isolation between the input and the output. It consists of a Rectifier/Battery Charger, Battery System, and inverter. The Battery Charger converts incoming commercial/utility AC power to DC power. This power is then supplied both to a Battery system and an inverter. The inverter then converts this DC power back into AC power which is fed to the critical load(s). The Battery is an emergency DC supply that is connected in parallel with the output of the Battery Charger, and supplies the DC power to the inverter (without any switching) in the event that the incoming commercial power is lost or outside of specified tolerances.

A true UPS is an on-line system, which means that under normal operating conditions, the power flow is through the Battery Charger, then through the inverter to the load. This differs from off-line, or stand-by systems, which are designed such that under normal conditions, power for the load is supplied directly from the commercial power source, NOT through the inverter. Depending on the design, and cost, the power may be conditioned by means of a Voltage Regulating Transformer or Power Conditioner placed in the power path between the commercial power source and the load. In an off-line or standby system, the inverter only supplies power to the load if the utility power fails. The Battery then picks up the inverter load for a finite period of time (typically 15–20 minutes). When the battery is depleted, the inverter will turn off, and the load will go down.

In order for a power supply to be considered a true UPS, it must accept three sources of power. The first source is the commercial, or utility, power that supplies AC power to the Battery Charger; the second is the Battery, which provides emergency DC power. The third source is a bypass, or alternate, AC source, which provides emergency AC power to the load if the inverter is unable to supply power, either because of an inverter failure, or a fault on the load. Under these conditions, the load would be automatically transferred to the bypass source via a static (electronic) transfer switch. The bypass source also supplies power in the event that the load is transferred manually from the inverter via a manual maintenance bypass switch.

A true on-line UPS is also referred to as a double conversion system. This means, as the name implies, that the power is converted twice. First it is converted from AC to DC at the Rectifier; then it is converted back from DC to AC at the inverter. Another common term is reverse transfer. This refers to the fact that the load, under certain conditions as described above (faults, equipment failure, or manual operation), is transferred back onto the commercial/utility power source. Again, this differentiates it from an off-line system where, under normal operation, the load is powered from the utility source.

How do I size batteries for UPS applications?

UPS batteries are sized to provide emergency back-up power to the UPS in the event of a total AC blackout. While it is often a matter of convenience or personal preference, the length of back-up time required is primarily a function of the process being protected. It is also governed by the cost of the battery.

Since a UPS is utilized to provide continuous power to a process of one kind or another, the batteries should be sized to carry the load for as long as it takes to either complete the process, perform an orderly shut-down of the process, or bring a generator on-line to power the load. A UPS inverter converts DC power to AC power. The battery must be sized large enough to provide the DC input power (in kilowatts) for a fully loaded inverter for the specified length of time. The DC input power is determined by applying the load power factor, and inverter conversion efficiency to the inverter’s AC power rating.

Next, you must determine the DC bus voltage, and the corresponding number of battery cells. Then, you can determine the battery capacity per cell required for the load. (Note that a battery has a nominal voltage of 2 volts per cell. So, on a nominal 120 VDC bus, you will need 60 cells.) Then, using discharge data supplied by a battery manufacturer, you can determine the battery type and size required.

Following is a typical battery sizing example: 20kVA UPS (inverter) with a DC to AC conversion efficiency of 87%; a load power factor of 0.8, and a nominal 120 VDC bus.

$$\frac{\left(\frac{20\text{kVA} \times 0.8}{87\%}\right)}{60\text{ cells}} = \frac{\left(\frac{16\text{kW}}{87\%}\right)}{60\text{ cells}} = \frac{18.39\text{kW}}{60\text{ cells}} = 0.307\text{kW/cell}$$

Using discharge tables supplied by the battery manufacturer(s), select the type of battery that meets the above requirements of 0.307 kilowatts per cell.

Please note that complex load duty cycle profiles, commonly referred to as step load profiles, should be referred to your UPS supplier for proper sizing.

What are the advantages/ disadvantages of different battery technologies?

There are several different types of batteries available for UPS applications. However, they basically breakdown into two technologies: Lead Acid and Nickel Cadmium. Lead acid batteries are further divided into two types: Lead Calcium and Lead Antimony. Lead Calcium batteries can be broken down into two categories: traditional wet cell (or flooded) and valve regulated lead acid, (or VRLA – sometimes mistakenly referred to as maintenance free). The proper battery for a given application is dependent upon a number of factors. (Refer to Table 1 below for a quick comparison between battery technologies.)

1. Ambient temperature

The optimum average ambient temperature for batteries is 77ºF. Ambient temperatures above that will significantly reduce battery life. The rule of thumb is that an increase in ambient temperature of 15ºF above 77ºF will reduce the battery life by 50%.

Certain battery types are more susceptible to the effects of temperature than others. For example, a VRLA battery with a 5 or 10 year design life is much more prone to premature failure due to temperature extremes than a wet cell with a 20 or 30 year design life. The least susceptible is the Nickel Cadmium battery. Although they are affected by temperature extremes, they can withstand slightly higher ambients than other types. But caution dictates that the same "rules" be applied to all batteries equally.

2. Number of discharge cycles

Batteries are rated in two general duty, or service, categories: "Float" service or "Cycling" service. Batteries considered to be in float service are only rarely called upon to carry a load. Cycling batteries (such as those designed for UPS applications), on the other hand, experience many discharge cycles over their useful life, with the depth of discharge ranging anywhere from several seconds, to a 100% discharge. Lead Antimony and Nickel Cadmium batteries typically offer the "best" cycling service. That is, they are designed to provide 2–5 times the number of discharges of other battery types, such as flooded or 20 year VRLA. 5 or 10 year VRLA, as you would expect, will accommodate the least number of discharges.

3. Maintenance

One of the trade-offs to using lead antimony batteries is that they expel greater amounts of hydrogen into the atmosphere when discharging. This requires more frequent maintenance, such as the addition of water. By far, the least amount of maintenance is required on the 10 and 20 year valve regulated batteries, since they do not expel hydrogen gas under normal operation. Lead calcium wet cell batteries do require some maintenance, and fall somewhere in the middle. Another aspect of maintenance for flooded batteries is the periodic measuring of specific gravity to insure the batteries are fully charged. All battery types require periodic tightening of battery terminals and connections.

4. Physical Size

Valve regulated batteries are designed for maximum power density. That is, they deliver a large amount of power per cubic inch. Nickel cadmium batteries also have a high power density. Typically, if battery room space is at a premium, a valve regulated or nickel cadmium battery may be the best choice, because you get "more bang for your buck" in a limited space.

5. Expected life/warranty

A 5 or 10 year valve regulated battery can be expected to last 2–5 years, depending on the number of discharges it experiences, the ambient temperature, etc. A 20 year wet cell or valve regulated battery will generally last 15–20 years, if properly maintained. A nickel cadmium battery may last 25–30 years. Battery warranties are typically one year full, with the balance pro-rated. In other words, a 20 year battery will carry a 12 month full warranty, with the remaining 19 years prorated against the manufacturer's list price. Extended warranties are often available.

One unfortunate thing about batteries is that, no matter how much you pay for them, they are essentially a consumable part, and need to be replaced periodically. Of course, there are many factors that affect how frequently this needs to happen, but eventually, even under ideal service conditions, they will need to be replaced. The real downside to this is that it is not always possible to predict exactly when the batteries are near their end of life although here wet cell batteries have a distinct advantage over valve regulated types. There are several ways to determine the status of wet cell batteries. 1) you can measure the specific gravity of a cell, and make determinations as to electrolyte levels; 2) you can measure cell temperature (which actually should be done in conjunction with specific gravity readings); 3) you can perform a visual inspection of the battery jar to determine the amount of sediment in the bottom; 4) you can perform a discharge test on the battery.

With VRLA batteries, though, because the jars are sealed, the best way to get an accurate indication of battery life and capacity is to perform a periodic discharge test. There are also several types of battery monitoring systems on the market, but the results of using those have been somewhat mixed.

6. Cost

With batteries, it is generally true that "You get what you pay for." Nickel Cadmium batteries offer the best overall performance – less susceptible to temperature extremes; greater number of cycles; greater power density; low maintenance; and greater life expectancy. However, the trade off is that the initial cost can be 2–3 times that of a 20 year wet cell lead calcium battery. A 20 year valve regulated battery is comparably priced (usually within 10–20%) with a 20 year wet cell battery. As you might expect, a 5 or 10 year battery is priced accordingly.

Battery type	Typical warranty	Life expectancy	Hydrogen gas evolution	Approx. number of deep charges	Initial cost comparison to lead calcium
Lead calcium wet cell	20 years	20 years	Low to moderate	100	100%
Lead calcium VRLA	10 years	5 years	None	200	3–50%
Lead calcium VRLA	20 years	15 years	None	200	80–120%
Lead antimony wet cell	15–20 years	15 years	High	400	100%
Nickel cadmium wet cell	20–25 years	20–25 years	Low	1000	250–300%

Why fuses instead of breakers for UPS distribution panels?

The goal of any well designed UPS system is to maintain power to the load at all times. However, since the output of the UPS is generally fed through a distribution panel board to the load, there may be times when an overload or fault occurs on one or more branch circuits that have the potential for dropping the load(s) on that branch. This condition needs to be limited to only that branch, and not affect any other loads, or upstream electrical equipment! Therefore, it is imperative that the fault condition be cleared as quickly as possible. Most molded case breakers, used as branch breakers in panel boards, take 2–3 cycles (50 milliseconds) before they will open under short circuit or fault conditions. Fast-acting fuses, such as the Gould Shawmut A25X™, however, have much faster clearing characteristics, typically 1/4 cycle (4 milliseconds).

Many UPS systems (inverters) will not provide enough fault clearing current for the 2–3 cycles required to clear those types of breakers. Fuse clearing energy of a power source can be expressed in terms of its I2-T capability. For example, a Cyberex inverter is able to deliver 150% of its rated output for 15 minutes without transferring to the bypass. A fault or short circuit of sufficient magnitude that is sustained for long enough could eventually cause damage or cascaded failures to other loads under what is referred to as panel pull-down.

Other types of inverters, which are not designed with the energy storage capability of Cyberex inverters, will only supply approximately 10–15% of the fault clearing energy of Cyberex inverters. This severely limits their ability to clear faults without transferring to an alternate source.

What is pulse-width-modulation (PWM)?

A PWM inverter employs high speed switching power devices to generate a series of "pulses" in the inverter bridge to "simulate" a sine wave. This signal is then filtered and fed to the load through a linear transformer. Due to the advanced technology behind the industrialized standard of using PWM inverters, it has a very tight voltage regulation during step loading and unloading be it 0–100%, 100–0%, 0–50%, 50–0% etc… of between 2–5% of nominal under any operating condition. Loads are not compromised due to step loading or unloading. Other technical benefits are higher efficiencies, smaller footprint, advanced metering/monitoring, and lower audible noise.

What is the CBEMA curve and what does it mean?

CBEMA stands for Computer Business Equipment Manufacturer's Association. The CBEMA curve defines the voltage tolerance levels and duration that computers and other electrical control devices, such as Programmable Logic Controllers (PLCs) can safely operate within without corruption of data. The curve shows that voltage transients of certain magnitudes, say 250%, are acceptable for short periods of time – 100 microseconds. That same transient with a duration of say 1/2 cycle (8.33 milliseconds) would cause disruption of data.

The curve also shows that voltage levels below nominal are also acceptable, provided they do not exceed the magnitude and duration defined by the curve. For example, a voltage deviation of up to -30% held for that same 1/2 cycle, would not cause a disruption of data. Indeed, the curve shows that voltage levels of even zero can be tolerated for a very brief period of time – say 4 milliseconds (1/4 cycle). By the way, that same zero voltage level sustained for longer than 1/4 cycle could wreak havoc on data. Losing voltage for only a little more than 1/4 cycle (8.33 milliseconds) seems insignificant, but for a computer, or other extremely sensitive equipment, it can be a lifetime.

The significance of the CBEMA curve in UPS applications is important when considering a UPS (or inverter) with an electronic (static) transfer switch. This switch is very critical to the overall reliability and up time of the UPS (and its load) because it is able to transfer the load off the inverter to an alternate AC power source to clear downstream faults when necessary, or in the event of an inverter failure. The ability to do this quickly and seamlessly is vital to the load. This seamless transfer must take place in both directions. Most static switches are designed to retransfer the load back onto the inverter after the fault or overload has been cleared. This retransfer should also cause no disruption of power. But, inevitably, there is a voltage deviation of some magnitude and duration when making this transfer. Therefore, it is extremely important to understand the implications of these voltage deviations. As has been pointed out, a voltage deviation of up to 30%, for example, can be tolerated for up to 1/2 cycle or more. Much has been made in the past of inverters that display a "lower" voltage deviation (commonly referred to as transient response) than some other types of inverters. However, the CBEMA curve shows that electronic devices don't care whether the level is higher or lower, just as long as it is within acceptable limits. A PWM inverter will always stay within the CBEMA curve and the acceptable limits of load power supplies.

How do I size my UPS?

Obviously, a UPS is designed and sized to provide **continuous** power to an AC load. The word continuous is a key word because many AC loads, such as motors, require a great deal more power (current) during start-up, than the actual "running" current. A typical rule of thumb is that start-up current for a motor, commonly referred to as "locked rotor current" is 8–12 times the actual running or steady-state current; otherwise you could end up with a UPS that is 8–12 times larger than what your load actually requires. It will be shown below how to avoid this problem when sizing your UPS.

The current measurement used to determine the load is the ***RMS*** value, rather than the ***peak*** value. (Note: If only the peak value is known, the RMS value can be determined by multiplying the peak value times 0.707). Once the load current is determined, the capacity of the UPS can be determined simply by multiplying the RMS current times the RMS voltage. This result is the Volt Ampere (VA) capacity required of the UPS. On 3-phase systems, multiply the result by $3\sqrt{}(1.732)$.

A phenomenon associated with today's electronic loads, such as computer, and control devices, is the introduction of switch-mode power supplies. These power supplies are non-linear in nature, and exhibit what is known as a crest factor. The crest factor is the ratio of the peak value of current to its corresponding RMS value. These crest factors can be anywhere from 1.414 (the ratio of peak to RMS current for a perfect sine wave), to 3 or 4, depending on the non-linearity of the load. However, for all practical situations, the crest factor is typically seen as 2–2.5.

Most UPS systems utilize a static (or electronic) transfer switch to transfer the load to an alternate AC source in the event that a fault or overload occurs that is beyond the overload rating of the inverter (typically 120%). In addition, most of these static switches have designed-in crest factor logic that differentiates between a true overload and a crest factor that often result from a switching power supply. This prevents the static switch from making "nuisance" transfers back and forth from the inverter to the alternate source. Therefore, although some manufacturers of DCS and other controls systems recommend that the UPS be sized to accommodate the crest factor, it is not necessary to do so. As stated previously, the UPS need only be sized for the RMS current.

Likewise when looking at motor applications, or other loads, that require a large amount of inrush current, the static switch allows the load to be started on the alternate source rather than the inverter. Once the load is stabilized, the static switch can then transfer the load onto the UPS inverter. That way, you can avoid the need for oversizing the UPS, and incurring unnecessary costs.

Industrial UPS – FAQs

Why single phase instead of three phase?

UPS systems are available in a variety of single phase, three phase, and so-called split phase voltage configurations. However, many loads in the industrial market are single phase only – particularly DCS, SCADA, and PLC applications. In years past, the EDP market – especially large main frame computer applications gave rise to a need for three phase UPS systems. There are, obviously, some three phase industrial loads, notably large motors, but by and large most industrial situations require single phase.

This is actually good news, because a single phase UPS offers some advantages over three phase systems. First, the fault clearing capability of a single phase inverter is approximately three times greater than a three phase unit. Downstream fault protection coordination is also easier to accomplish with single phase.

Second, there are no loads to balance. When using a three phase inverter to drive single phase loads, care must be taken that loads are balanced within a few percent of each other. Load imbalance can lead to voltage regulation that is out of spec, as well as increased harmonics, which can lead to distortion in the output waveform and/or overheating.

Single phase distribution panel boards and switchboards are less expensive, smaller, and easier to work with than three phase units. Again, since industrial controls systems for the most part consist of single phase loads it probably doesn't make a lot of sense to install three phase panels and inverters in the distribution system. This is likewise true for so-called split phase distribution systems. Many panel boards are rated for 120/240 volt operation. Therefore, many electricians think that they need to provide an inverter (UPS system) with a 120/240 volt output, rather than a straight 120 volt output, even though the actual loads are only 120 volts. In reality, a 120 volt unit is what they need – all they need to do is split the loads at the panel board. Many panel board manufacturers will make a straight 120 volt panel if requested to do so, usually at no extra cost.

Although it may be a trade-off at higher power levels, it can be easier and less expensive to run cables for a single phase system. The trade-off comes when taking into consideration the breakers and cable sizes.

In general, unless you truly have some three phase loads, then, it is usually a better bet to use a single phase UPS, rather than three phase. Check with your UPS supplier to make sure that they can provide a single phase system, even at higher power levels – say 75 or 100kVA. Even at those ratings, the advantages of single phase may outweigh the perceived installation cost savings of three phase.

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