
Uninterruptible Power Supply (UPS) Planning and Installation Guide



Solidstate Controls Incorporated
875 Dearborn Drive
Columbus, Ohio 43085
Tel : (614) 846-7500
Fax: (614) 885-3990

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Preface

Solidstate Controls, Inc., is pleased to furnish this Planning and Installation Guide to inform you about the UPS equipment and assist you in its installation.

The planning for an installation of electrical equipment as critical to your company as an uninterruptible power system (UPS) deserves, and in some localities requires, the attention of a qualified engineer or qualified electrician. SCI is pleased to assist you or your technical staff in any way and has prepared this manual as a technical aid. However, nothing herein should be construed as a substitute for proper engineering of a specific installation.

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How To Size Ups Loads

Good data on power consumption is often hard to get for small loads such as personal computers.

Most equipment below, for example, 800 Watts, will be 120 VAC, single phase, 60 Hz. rated (Sometimes with a dual rating for 50 Hz. And 240 VAC for overseas usage).

Usually, each component of the computer system will have a tag placed near the location the power cord enters the device.

Underwriter's Laboratory (UL) requires that at a minimum, the voltage, amperage, and frequency be identified.

The arithmetic product of the voltage and the amperage, i.e., $V \times A$, gives a result in Volt-Amperes often stated simply, VA. The Volt-Ampere (VA) is a universally accepted measure of electrical capacity for the UPS industry.

VA capacity simply states that a given device may draw so many amps (A) at a particular voltage (V). *This is often a worst case value.*

Many computer manufacturers overstate their equipment capacities by 20% or so to insure that the user provides adequate electrical service to the system.

The VA capacity tells us nothing about how efficiently the device utilizes the energy it receives. The measure of actual electrical energy usage is the watt (W.).

Sometimes the device label will state a wattage value, and this is particularly true for small loads below 800 watts. Many small UPS systems will have their capacity stated in watts rather than volt-amperes.

The ratio of watts over VA, i.e., $W \div VA$ gives us a measure of power utilization called the power factor (p.f.).

For example, a computer with a volt-ampere rating of 120 VA, and a wattage rating of 96 watts has a power factor of 0.8.

$$\frac{96 \text{ watts}}{120 \text{ VA}} = 0.8 \text{ p.f.}$$

A good rule of thumb is to assume a power factor of 0.8 if both the wattage and volt-ampere rating are not known.

For example, an IBM desktop computer, the PS/2 Model 30 has the following label attached in the back:

CPU	B/W Monitor
100-125 VAC	100-125 VAC
1.5 A	.9 A
50/60 Hz.	60 Hz.

Notice that the wattage is not known nor is the power factor. Since in the U.S., 120 VAC is the nominal value of input voltage, we can calculate the CPU's volt-amperes (VA) directly:

$$\text{IBM CPU} - 120 \text{ V} \times 1.5 \text{ A} = 180 \text{ VA}$$

If we use our rule of thumb and assume a power factor of 0.8, then

$$180 \text{ VA} \times .8 = 144 \text{ Watts (W)}$$

For those who love details: The value difference between 180 VA and 144 W, 36 VA circulates as unused power between the input power source and the computer.

So at this point we have two numbers 180 VA and 144 W, which one do we use? It depends on how the UPS capacity is stated.

The SCI Powerbase UPS have their capacities stated in Volt amperes, but the DataShield UPS have their capacities stated in watts. Use whichever number is appropriate to the UPS system selected.

So far, we've only covered the CPU but the calculations for the monitor are similar:

$$\text{IBM Monitor} - 120 \text{ V} \times .9 \text{ A} = 108 \text{ VA} \quad 108 \text{ VA} \times .8 = 86 \text{ W}$$

Recap:

CPU	VA	Watts
IBM model 30 CPU	180 VA	144 W
IBM B/W Monitor	<u>108 VA</u>	<u>86 W</u>
System Total	288 VA	230 W

Thus we should be looking at a UPS with a V rating of 300 VA or a wattage rating of approximately 240 W.

Notice we're being conservative in that the derating factor of 20% was not used. It is good design practice to oversize the UPS to take care of those equipment additions such as tape drives and modems that invariably get added to the computer system later.

In larger computer systems such as those supplied by IBM, DEC and Data General, detailed computer printouts listing the volt ampere, wattage and peak current of each device can be obtained from the computer manufacturer's local sales office.

These print outs are essential for accurate, comprehensive sizing of the UPS system!

We have not mentioned three phase power which is found in larger computer systems, but the principles are much the same; i.e., the individual device volt ampere (VA) ratings can be directly added to produce a composite value. In these larger 3 phase systems (typically above 10,000 VA or commonly written 10 KVA) wattage is almost never used as sizing measure.

Three phase loads can be difficult to size, especially if there is a mixture of both single and three phase devices in the system. Please call SCI for sizing assistance for those three phase applications.

For the truly dedicated, Section III of the SCI UPS Installation and Planning Guide discusses three phase applications.

Section I: Electrical Considerations

A. UPS Sizing – Load Study

The first step in sizing the UPS is to perform a thorough Load Study. When performing the Load Study, it is important that all possible considerations be made for present needs and any planned future expansion. All loads need to be analyzed with respect to various parameters, as described below. The following is a discussion and examples of which loads need to be considered for a computer room and how to use this information in sizing the UPS. The same procedure can be used for load studies for any critical load:

1. Computer Main Frame or CPU
2. Printers
3. Disk Drivers
4. Plotters
5. C.R.T. Terminals
6. Any Other peripherals
7. Emergency room lights, alarms, security, and all other loads which must be supported when the computer is in operation.
8. Any other DC loads
9. Any projected expansion in the near future. Consider the planned addition of any peripherals, CRTs, printers, etc., or new or additional computers. (It is more economical to purchase one large UPS than two smaller ones to equal the same KVA rating.)

Identify the voltage of each load, whether it is single phase, two phase, or three phase, and the frequency.

In an effort to minimize the size of the UPS, and correspondingly the cost, one should consider which devices, if any, need not be powered from the UPS. For example, if a computer room application requires only time to properly power down the system, then you need not necessarily power your tape drives. Also, suppose there are ten (10) terminals connected. Only one is necessary to power down. In this way, one can minimize the initial cost by purchasing a smaller size UPS, which is likely to require less floor space, less air conditioning, and less annual operating costs.

If some loads have different input voltages, it should be determined if they are convertible. For example, the main frame may be able to accept either 208Y/120 VAC, three phase, or 240 VAC, three phase inputs. If all other voltages are 120 V or 208Y/120 V, then 208Y/120 V should be selected to power the main frame. This will eliminate the need for, and additional cost of, special voltage transformers.

If any of the loads are three phase, then a three phase UPS is required.

A single phase UPS with a 120 V output can supply only a 120 V load. However, a three phase UPS with a 208Y/120 V output can supply either a 120 V single phase load, a 208 V two phase load, a 208 three phase load, or a 208Y/120 V, three phase load.

In determining the size of a three phase UPS, single phases loads can be distributed between each of the three phases. However, one large single phase load can be connected to only one phase of a three phase UPS. This one load may well determine the size of the system, even though the other loads may be very small.

Example

STEP 1 – Identified Loads

1 phase 120 V loads	2 phase 208 V loads	3 phase 208 V loads
75.0 amp	1.5 amp	12.0 amp
.5 amp		5.0 amp
3.5 amp		1.5 amp
7.0 amp		
2.5 amp		
5.0 amp		
3.0 amp		

STEP 2 – Balancing Loads

Three Phase UPS Output

A phase	B phase	C phase	
75.0	5.0	2.5	1 phase loads
	7.0	3.0	1 phase loads
		3.5	1 phase loads
		0.5	1 phase loads
	1.5	1.5	2 phase loads
12.0	12.0	12.0	3 phase loads
1.5	1.5	1.5	3 phase loads
<u>5.0</u>	<u>5.0</u>	<u>5.0</u>	3 phase loads
93.5	32.5	29.5	

STEP 3 – Select UPS Size

The actual minimum kVA required is calculated by multiplying the highest phase current times the line-to-neutral voltage, times three, divided by 1000.

$$\text{kVA} = \frac{\text{Amps (highest)} \times \text{Voltage (line-to-neutral)} \times 3}{1000}$$

$$\text{kVA} = \frac{93.5 \times 120 \times 3}{100} = 33.66 \text{ kVA}$$

Selecting from our standard sizes, we find that we must supply a three phase, 40 kVA UPS which has a 111 amp AC output per phase. One can see that “A” phase is 84% loaded, while “B” and “C” phases are only 27% loaded, which means that there is substantial room for additional single phase loads for future expansion – but only limited expansion room for three phase loads.

In the previous example, we have been looking at continuous full load currents. Any load which has a significant inrush current must also be identified. In order to avoid an overload of the UPS, it may be necessary to power-up the various loads sequentially. It may also mean that the way the loads are balanced on a three phase UPS may need to change so that all the high inrush loads are not on the same phase, if possible.

In the earlier example, if the 12 amp, three phase continuous load had an inrush of five times its continuous rating (60 amp inrush), and if all other loads on “A” phase were “on” and we attempted to start the load, a total load of 141.5 amps would be seen on “A” phase. This would cause an overload and all loads would be transferred to the bypass source until the overload was cleared. If this is likely to happen often, the consideration should be given to installing a large UPS. Note that SCI inverters are designed to transfer to the bypass source upon an overload of 120-125% of full load.

As shown in the previous example, if the 5 and 7 amp loads on “B” phase both had inrushes of ten times their rating and both could start at the same time, then an overload would occur. In this case, consider moving one of the loads to “C” phase and perhaps an equal amount of load could be moved from “C” phase to “B” phase.

There are usually many load considerations which must be looked at in sizing the UPS. Be sure that all possibilities which might jeopardize the integrity of the continuous power have been considered.

B. UPS Sizing – Estimating from Available Data

It may be necessary, for quotation purposes, to estimate the size of a UPS required for a particular installation where time does not permit a detailed Load Study.

1. With all equipment operating, one method would be to use a clamp-on ammeter.

For a single phase, two-wire system, measure the hot leg. The kVA rating is calculated by multiplying the measured current times the line voltage, divided by one thousand:

$$\text{kVA} = \frac{\text{amps} \times \text{voltage}}{1000}$$

For a single phase, three-wire system (240/120), measure each hot leg. The kVA rating is the highest current reading multiplied times the line-to-neutral voltage, multiplied times two, divided by one thousand:

$$\text{kVA} = \frac{\text{amps (highest)} \times \text{voltage (line-to-neutral)} \times 2}{1000}$$

For three phase systems, measure all three hot legs. The kVA rating is calculated by multiplying the highest current reading times the line-to-neutral voltage, times three, divided by one thousand:

$$\text{kVA} = \frac{\text{amps (highest)} \times \text{voltage (line-to-neutral)} \times 3}{1000}$$

If it is not possible to measure the actual current, it may be necessary to use one of the following:

2. Obtain load profile from manufacturer for the individual loads. This will probably be necessary for new installations. Add to this any lighting, alarms and security loads which are required.
3. In existing installations, check the capacity of the step-down isolation transformer supplying the critical load or check the size of the distribution panel feeding those loads.
4. It may be necessary to contact the electrical contractor who installed the loads for load data.

In these last three cases, be sure to determine if there are any three phase loads. Even though there is a three phase distribution panel or isolation transformer, there need not necessarily be any three phase loads.

C. Crest Factor Capability

Included in SCI UPS equipment is circuitry to allow the inverter to be compatible with loads exhibiting a high crest factor. Today's electronic computers and instrumentation equipment are powered with high frequency switching power supplies, which draw non-linear current from the AC source. [Both SCI's Ferroresonant and our power transistor PWM UPS systems have the designed capability to supply these non-linear high crest factor loads.](#) Without this capability the UPS will either need to be over-sized or will experience unnecessary and potentially load damaging nuisance transfers, while these high crest factor loads are operating.

For further information about non-linear loads and crest factor control, please refer to our technical paper on the subject.

D. Electrical Service for the UPS

The Power source must be of sufficient capacity to handle the worst case demands for the UPS.

Primary power installations for the UPS is the responsibility of the customer. Future expansion should be considered in determining power requirements. The customer is also responsible for the installation of any input distribution panels, external battery disconnect switch as required by the NEC and/or local codes, output distribution panels and wiring to the loads, unless such has been bid by SCI as part of the customer package.

Input Power Considerations and Distribution

Consideration must be given to the input distribution panels for the UPS. What presently exists for the load may not be too small, due to the losses in the UPS itself, the additional battery recharge capability, and the overload capacity of the rectifier/charger. Some installations may have chosen a larger rectifier/charger than that which would normally be supplied, due to some additional DC loads or the customer's desire to recharge the batteries at a faster rate. The maximum current ratings provided should be consulted for this determination.

It might appear on the surface that this device is very inefficient, due to the rectifier/charger high input current. This is not the case. Our rectifier/chargers are approximately 92-94% efficient.

The reason for the high input current is this. The output voltage regulation of the rectifier/charger is accomplished by controlling the conduction interval of the thyristors. This is done by gating on the thyristors at the proper time during each half cycle. This change of conduction interval allows the

unit to maintain a constant output voltage with a varying input voltage. A longer conduction period increases the DC output voltage and, conversely, a shorter period lowers the output voltage.

When the input voltage is high, the thyristors are gated on later during each half cycle. As a result, in order to provide constant power, we will necessarily see a high current spike at this point which we will refer to as form factor or crest factor. Consequently even though the kilowatts (KW), which you pay for at the electrical meter, are what you might expect based upon 92-94% efficiency, this "form factor," or "crest factor," causes a higher-than-normal peak current demand which must be considered when selecting all upstream devices. (Note: Although not true power factor, this form factor or crest factor, is many times expressed in those terms when discussing input requirements for rectifier/chargers.)

In general, a good rule of thumb for estimating the input power requirements for a UPS system is to use 2.5 times the output kVA rating for our Ferroresonant units and 2 times the output rating for our PWM units.

All wiring, transformers, distribution breakers, etc., must be sized for the maximum currents, as dictated by the NEC, even though, under normal operating conditions, the input current can be expected to be much lower.

The following formula can be used to derive the rectifier/charger input power requirements expressed in (VA) volt amperes.

$$\begin{aligned} \text{CIP} &= \frac{V_e \times A_r \times C_1}{\text{PF} \times \text{EF}} \\ V_e &= \text{Charger equalize voltage} \\ A_r &= \text{Charger rated output in amperes} \\ C_1 &= \text{Charge current limit point (typically 1.2 to 1.25)} \\ \text{PF} &= \text{Charger input power factor (typically 0.8)} \\ \text{EF} &= \text{Charger efficiency (typically 92-94\%)} \\ \text{CIP} &= \text{Charger input power in (VA) volt amperes} \end{aligned}$$

The following formula can then be used to derive the rectifier/charger maximum input current. This information is necessary in determining the UPS system input electrical service requirements.

$$\begin{aligned} A_c &= \frac{\text{CIP}}{V_1 \times 3} \\ V_1 &= \text{3 phase AC input voltage at low line (typically nominal voltage -10 or -15\%)} \\ 3 &= 1.732 \\ A_c &= \text{charger input current in amperes} \end{aligned}$$

Note: SCI can provide adjustable current limiting from 100% to 125% to aid in limiting the input current requirements under conditions where maximum current limiting is not desirable.

E. Bypass Source Supply

The bypass source input must be supplied with an input voltage and frequency which exactly matches the output of the UPS. For example, if the UPS system output is 208Y/120 Vac, 60 Hertz, then the bypass source input must be 208Y/120 Vac, 60 Hertz. If this matching voltage is not available, an appropriate transformer must be installed to provide the proper voltage. SCI can

supply this transformer mounted in a matching cabinet, if desired, or can supply a standard transformer of another manufacturer in their own floor-mounted enclosure. Some customers may wish to have their own electrical contractor supply and install this along with other necessary equipment.

F. Output Distribution Panels

The customer's existing distribution panels, which previously supplied the computer loads, should be re-evaluated before utilizing with the UPS. The inverter portion of the UPS can deliver only a small amount of current above its nameplate rating before the output voltage drops off drastically. Consequently, the current available to trip the distribution breakers is severely limited. Ideally breakers and/or fuses should be selected to clear the possible faults without overloading the inverter. When overloads do occur, the static switch will transfer all loads to the bypass (utility) source without interruption, where the large capacity will clear the fault. Since all transfers involve some risk to the load, all unnecessary transfers should be avoided.

For further information regarding fault protection, please refer to "UPS Systems Distributor Network Protection" by Laura Andrei, R & D Engineer.

G. Consideration Regarding AC Distribution for Computer Rooms

An Uninterruptible Power System (UPS) is the most complete form of power conditioning available. A UPS can provide complete protection from all forms of line voltage transients, surges and sags, long duration brown outs, and is the only device which can provide total 'no break' back-up protection against black outs.

It is commonly recognized that the various voltage related problems that trouble your computer come from two sources. The first is atmospheric and accounts for approximately 20% of the total power problems. The remaining 80% occurs within the users own building. This is a result of a variety of conditions such as the presence of noise generating equipment like contactors, relays, switches and fluorescent lighting, a general high power demand and the present of high inrush loads like motors and other large inductors. Power problems also occur in the AC distribution system as a result of distribution breakers with dirty contacts which result in high impedance, poor connections including ground connections, incorrect grounding practices, improperly sized ground neutral and power conductors and wiring errors. Surprisingly, wiring errors such as ground-neutral reversals, poor or loose connections and improper wire sizes occur frequently, even in systems which have been in use for a long period of time, and are unknowingly causing computer room problems.

The UPS can correct all voltage problems caused by the various previously mentioned conditions which exist up to the point of input to the UPS itself. However, if the AC distribution system which exists between the output of the UPS and the various computer loads and peripherals has any of the previously mentioned problems, voltage fluctuations may be re-introduced onto the clean power generated by the UPS and, as a result, trouble with the computer system may continue. It is, therefore, to the user's benefit to be sure that this AC distribution system is designed and operating properly. One would be cautioned not to assume that your AC distribution is error free, but that it be properly analyzed by experts in that field.

Many such AC distribution systems have been designed by experts and have AC verifications performed periodically (at least one a year) to assure that everything is operating properly, that vibration has not loosened any connections, that circuit breakers have clean low impedance contacts, that no loads have been added improperly and that breaker and wire current ratings have

not been exceeded. If this is not being done, one would be advised to contact experts in that field to aid you in performing this important periodic analysis.

One should also be aware that some computer peripherals, such as printers, are themselves noise generators, and that proper filters should be used on these lines to prevent the transmission of this noise from one device to another.

H. Long Term Power Back-Up – AC Engine Generator

There are several options open to the customer to supply his critical load in the event of a long term power outage. One is to provide a battery bank large enough to carry the load for the prescribed length of time (see discussion of “Battery Sizing/Selection/Installation”). The other is to utilize an engine generator which can supply the load almost indefinitely. If the customer has an existing engine generator, he may wish to utilize it for back-up purposes. There are, however, a number of points which should be understood before using an engine generator.

Even though an engine generator can be used for long-term back-up, batteries will still be needed. In the event of a power outage, the engine generator will need to be started. If it has not been started for some time, there may be some difficulty getting it started. Once started, it will need to be brought up to speed before a steady voltage and frequency is established. During this period of time, batteries will be needed as back-up to the UPS.

The engine generator probably cannot supply the computer directly. Although the engine generator is adequate for loads not requiring precise power, such as lighting, this is obviously not adequate for the computer. The nature of the engine generator is such that we can expect both voltage and frequency to be constantly varying. The proper method of utilizing the engine generator for long term back-up is to supply power to the Rectifier/Charger, thereby utilizing the UPS for voltage and frequency regulations.

The engine generator manufacturer should also be made aware that the load will be of an SCR-type.

For estimating purpose, the required engine generator should be approximately 2.5 times the kVA rating of the UPS. Please refer to SCI for specific data on specific equipment.

NOTE: SCI can provide logic to cut back current limit while operating from the generator to help minimize the input requirements.

I. Long Term Back-Up DC Engine Generator

An alternative to the use of an AC engine generator is the use of a DC engine generator. In this application the generator size can be smaller due to the fact that the only over-sizing required is that necessary to overcome the inverter losses. Circuitry can be designed so the generator does not attempt to recharge the battery. The generator size need only be from 1.3 to 1.5 times the kVA rating of the inverter.

J. Grounding

All SCI UPS enclosures are provided with grounding terminals located at the bottom. Equipment should be grounded in accordance with the National Electrical Code and applicable local codes. The electrical contractor will be aware of this necessity. A good current reference is FIPS PUB 94, titled Guidelines on Electrical Power for ADP Installations, dated September 21, 1983. A copy of this can be obtained by writing to the National Bureau of Standards.

Section II: Physical & Environmental Considerations

Site selection and planning

The site selected for the UPS should be chosen with care since the type and amount of site preparation required will vary according to the specific location and its relative location to the load.

A. Locating the UPS

The relative location of the UPS to the load is important for several reasons. First, the greater the distance between the UPS and the load, the longer will be the interconnection cables; the longer the cables, the larger the wire will need to be in order to minimize the voltage drop in the wires. This means greater expense. For example, a 20 kVA UPS with 120 VAC single phase output of 167 amps, if used with 2/0 gauge wire, has a voltage drop of 2.7 volts in 200 feet. The a 500MCM cable, the voltage drop is only 0.7 volts. However, 500MCM wire is almost four times the size of the 2/0 gauge and proportionally more expensive. Second, and most important, is the fact that these longer cables are more likely to pick up electrical noise from outside sources than are shorter cables, simply because they are more likely to pass near noise generating equipment or other noise carrying conductors. The elimination of electrical noise is one benefit of the UPS. It is important to keep these cable lengths as short as possible and removed from the proximity of other cables or noise generating equipment such as motors, switches, etc. If long cable runs are unavoidable, greater care should be exercised in cable routing and sizing.

B. Floor Space Requirements

The Inverter and Rectifier/Charger

It is important that adequate floor space be provided for the UPS electrical equipment. Check the dimensional information on the appropriate data sheets for the floor space requirements. The UPS equipment can be mounted with the back against a wall. Side access is not specifically required; however, if side and rear access can be maintained, it may be helpful should service become necessary. A clear area in front of the unit of at least five (5) feet should be maintained for service personnel.

C. Ventilation Clearance

In order to provide for adequate ventilation, the UPS should be installed in a room which has a least 12 inches of clearance over the unit. The area above the UPS should be clear of any obstruction which would impede air flow. Since cooling air enters through a grill at the bottom front of the equipment, this area must also be kept clear of any obstructions.

D. Floor Loading

The Inverter and Rectifier/Charger

Some of the larger UPS systems are relatively heavy. Care should be taken to assure that the floor loading requirements are not exceeded. Reference can be made to the appropriate literature for dimensions and weights. Floor loading can be expected to vary from 90 lbs. Per square foot on smaller units to over 300 lbs. per square foot for our very large units. One should plan accordingly.

E. Equipment Mounting Requirements

The Inverter and Rectifier/Charger

This equipment is designed to set on any floor which is adequate to handle the loading. No bolting to the floor is required, although some units have provision for bolting should the customer wish to do so.

F. Inverter and Rectifier/Charger Room Requirements

Room Temperature

All SCI Ferroresonant UPS systems are designed to operate at full load in an ambient temperature of 0-40°C (32-104°F); 0-95% relative humidity; to altitudes of 5,500 feet (over 5,500 feet, consult the factory). All SCI Powerbase (PWM) UPS systems to altitudes of 4,920 feet. However, as with all electronic equipment, operating over a prolonged period of time at elevated temperatures may be detrimental to the extended life of the equipment. In all probability we would expect the normal temperature range to be between 70-80°F.

Some installations may require that equipment be designed to operate at 50°C (122°F) for periods of time when normal cooling or ventilation has failed. SCI can design equipment to meet this parameter where it is determined to be necessary.

High temperatures do have a negative effect on virtually all electronic components. For maximum service life, plan the equipment room so that normal operating temperatures are between 65-90°F.

Appendix A shows actual worst case heat dissipation for our standard equipment which will aid you in determining ventilation and air conditioning needs.

Since products do change frequently, you may contact SCI to verify current heat dissipation data.

Cleanliness

The equipment room should be relatively free of dust and dirt and other airborne contaminants as heavy layers of dust will reduce the cooling efficiency of the electronic components.

Humidity and Condensation

It is important that the room low temperature control be adjusted to maintain the room temperature above the dew point in order to prevent condensation of moisture on the electrical equipment.

G. Unloading and Route Inspection

Unloading Facilities

Before the UPS equipment arrives at the installation site, a number of checks need to be made of the facility. Specific equipment size will determine the importance of each of the following items. First, check if the site has an adequate loading dock or an unloading area that is accessible to the trucker. If unloading facilities are not adequate, one might consider unloading at some other location which has proper facilities; perhaps a nearby business that is willing to cooperate, and using a smaller truck to deliver equipment to the site, or using the services of a professional moving company.

Moving Equipment

At the unloading area, a forklift may be needed to remove the equipment from the truck. The forklift capacity should be checked to be sure it is adequate to handle the weight of the equipment. This information is available from the data sheets.

Note that the data sheets give total weight. If the outline drawing shows two equally sized cabinets, the weight should be divided with approximately 60% in one cabinet and 40% in the other. If the outline drawings show one larger and one smaller cabinet, the weight should be divided with approximately 75% in the larger and 25% in the single smaller cabinet.

Route Inspection

Determine how the equipment will be moved from the unloading area to the installation room and examine the passageway through the building to determine if there is adequate clearance to move the largest and heaviest package. Remember, add to the height the lift truck, dolly, or other device that will be used to move the equipment. Especially check doorways or places where the equipment must go around a corner for proper clearance. If an elevator is going to be used, be sure the lift capacity and size is capable of handling the largest and heaviest package. If a lift truck, moving dollies, etc., are not available, these should be rented or otherwise secured and be available when the equipment arrives.

H. Fire and Safety Precautions

In most cases, building fire and safety codes establish the degree of protection required for installation of electrical equipment and batteries. These should be followed for the installation of UPS systems.

Caution should be used to assure that the UPS is removed from areas in which flammable or explosive materials are kept or manufactured.

Personnel should be instructed in emergency shut down procedures.

Electrical equipment can pose certain hazards to equipment maintenance personnel.

ONLY QUALIFIED PERSONNEL SHOULD BE ALLOWED
TO PERFORM MAINTENANCE ON THE EQUIPMENT.

I. Security

Security of the UPS room or location is as important as security of your computer room or other limited access area. There is a potential for damage to the equipment as a result of ignorance, carelessness, or vandalism. In addition, an inexperienced operator could cause a loss of power to your critical load by improperly manipulating the various controls on the UPS. Consequently, one may wish to limit access to the UPS area and monitor entry through your comprehensive alarm system.

J. Storage of Supplies

SCI recommends that the customer purchase and keep on hand replacement spare parts for the electrical equipment. See Section VI of this manual. These parts should be stored in a clean, dry

location which is subject to the same temperature variations as allowed for the Inverter and Rectifier/Charger, i.e., 32° to 104°F.

K. Vibration

Standard UPS equipment is built to withstand mild, intermittent building vibration. However, the equipment should not be considered to be seismic or earthquake proof.

It is impossible to predict a designed vibration tolerance for conditions that might be encountered in various installations. If this is a concern, it should be discussed with a SCI factory engineer. SCI has vast experience in designing and qualifying seismic equipment.

L. Nuclear Class 1E Qualified Equipment

SCI has a comprehensive program to provide Nuclear Class 1E equipment. All such equipment is custom manufactured to the specific requirements of that particular location. For detailed information please contact SCI.

Section III: Battery Selection

All SCI UPS Systems are designed to operate from virtually any commercially available battery bank which exhibits the proper voltage range and current capacity to power that particular UPS.

Choosing the proper battery for the application then becomes one of examining these various parameters and choosing the one most suitable for the particular application. The following is an analysis of various battery types and methods for sizing these batteries utilizing the battery manufacturer's data.

These batteries fall into two general types: Stationary and sealed.

Stationary batteries are those which require ventilation due to the fact that they are designed to release gases into the atmosphere including hydrogen when they are charging. Consequently, these batteries also require routine maintenance such as periodic watering, specific gravity, and voltage checks. In general, these batteries are longer-lived than sealed batteries.

Sealed batteries are those which are essentially sealed and release only small amounts of gas under high internal pressure as a safety precaution. This would probably be a result of severe overcharging. Normally, the hydrogen and oxygen gases generated as a result of battery charging, recombine within the battery as water. No watering is necessary or possible.

The following batteries are examples of types normally used for UPS back up.

1. Lead Calcium – Stationary Batteries

This type offers the best cost versus service reliability for stationary batteries available for UPS installations. These batteries typically carry a 20-year warranty and have a 20-25 year life expectancy when used under float conditions. Hydrogen generation is low compared to lead antimony batteries and when maintained at a float voltage of 2.25 volts/cell, do not require routine equalization. Maintenance consists of watering, terminal cleaning, and checking electrolyte specific gravity at six-month intervals. Equalization is necessary only upon initial energization.

2. Lead Antimony – Stationary Batteries

These batteries generally are equal in size and capacity to the lead calcium batteries. Usually they are warranted for 15-20 years, with a life expectancy of 15-22 years. These batteries are normally better suited for applications where they are cycled rather than in full float application. Hydrogen generation is considerably greater than lead calcium batteries and maintenance is required more frequently, including periodic (monthly) equalization, and weekly watering checks with additions as necessary.

3. Nickel Cadmium – Stationary Batteries

NICAD batteries are the most expensive of the stationary types discussed, costing approximately two to three times calcium batteries. Although it requires 92 cells of nickel cadmium to equal 60 cells of lead calcium, they still have an advantage in being smaller in size and weight for a given capacity. They also have excellent low temperature and high temperature properties and have an exceptionally long service life even at high temperatures. Service life expectancy under normal conditions is approximately 25 years or more.

4. Sealed (Maintenance Free) Batteries

As previously discussed, sealed batteries are those which, due to special construction, do not normally vent gas into the atmosphere, and because they are sealed, require no routine water additions. Because they do not gas, they are well suited for installation into an office area or computer room environment where special ventilation would be difficult or impractical to provide. These two advantages present cost savings which should be considered when evaluating your battery requirements. Sealed batteries lend themselves well to cabinet mountings, and as a result can be attractively packaged for installation in an office or computer room along with the UPS system. One can also recognize sealed batteries by the use of names such as Gel Cell, Absorbed Electrolyte, Starved Electrolyte, or Suspended Electrolyte.

A word of caution. Sealed batteries are maintenance free only in the sense they require no electrolyte checks or water addition. It is important that the battery terminal connections be inspected and re-torqued periodically to maintain a sound connection.

Life expectancy and manufacturer's warranties vary from 1 year to 20 years with a corresponding variation in price. As an average, a 10-year sealed battery on an open rack will be priced approximately equal to the lead calcium 20 year wet battery.

Section IV: Battery Room Physical And Environmental Consideration

A. Battery Room Temperature

Since battery operation results from a chemical reaction, temperature plays a significant role in performance and life. A standard temperature of 77°F (25°C) is used to rate the batteries. It is recommended that the battery room temperature be maintained as close as possible to this temperature (72-80°F would be acceptable).

Care should be taken not to locate batteries where they will be in direct sunlight or near a register which might subject one or more cells to high or low temperatures. The temperature differential between all cells in a battery bank should no be more than 5°F. Although battery capacity improves considerably at higher discharge rates as the temperature increases, there is also a significant decrease in battery life. An increase in periodic maintenance, especially watering, can also be expected with stationary types.

Sealed batteries are less tolerant of high temperatures than are wet batteries. If average daily temperatures in the battery room exceed 92°F, you would be advised to consider using only wet stationary battery type.

When batteries are operated at temperatures below the standard of 77°F, the available capacity and consequently, the back-up time is reduced. It is significant to note that the percentage decrease in operating time will be greater than the percent loss of capacity and varies with the rate of discharge. The effect is greater at high discharge rates, such as fifteen minutes, than at lower discharge rates, such as eight hours. Also, since the charging voltage was based on 77°F, reduced temperatures will result in increased recharge time, a likelihood of cell imbalance and consequently, a need for equalization.

B. Physical Considerations

1. Floor Space Required

Various styles and sizes of battery racks are available. The selection of racks will probably be based on available floor space. The two-tier and two-step racks will provide for easier servicing of the battery; however, the three-tier and three-step racks will save floor space. For sealed batteries, cabinets offer the most efficient use of floor space.

Battery banks are heavy, and consequently, floor loading may be a critical consideration. Be sure the floor will be adequate. Floor loading over 600 pounds/square foot can be expected with some battery bank and rack combinations. Obtain floor loading requirements for the proposed location. Floor loading requirements may also help determine the type of racks which can be used in a particular location.

Standard two-tier racks are the most economical and most commonly used models in commercial and industrial applications. They do not include any side or end rails to restrain the battery cells. Your building code may require shock-protecting racks for Zone 1 area applications, or seismic racks for Zones 2, 3, or 4 applications. If these racks are required, SCI can quote prices and supply dimensions. These racks are generally not available in space-saving three-tier or three-step designs. Most sealed batteries in cabinets are suited for UPC Zone 4 applications. Since stationary batteries do require some routine maintenance, adequate space must be allowed around the battery bank to accommodate safe and efficient maintenance. The cells need to be visible in order to check electrolyte levels and be accessible when specific gravity and cell voltage checks are required.

2. Ventilation

All stationary batteries produce hydrogen gas while they are being charged. Gassing does not become a problem until approximately 70% of the charge has been returned to the cells. The battery room must have adequate ventilation, preferably to the outside, to prevent the build-up of hydrogen gas in the room.

The size of the room and the size of the battery bank will determine the amount of ventilation required. As a general rule, ventilation should be adequate to provide from one to four air exchanges per hour.

Batteries do not gas when they are being discharged, only when they are being charged. Consequently, loss of ventilation during a power outage is not a problem, unless a critical operating temperature is reached in the room as a result.

C. Electrical Consideration

The end voltage is the minimum voltage that the cell will be allowed to reach during discharge. In general, with lead acid batteries, it is recommended that the per cell end voltage not be allowed to go below 1.75 volts per cell for long-term discharge batteries (those over 60 minutes), and 1.67 volts per cell for short-term discharge batteries (those 60 minutes and below). The UPS DC voltage windows will also need to be compatible and should first be consulted. This is necessary to prevent possible damage to the batteries. To accomplish this, the UPS should be equipped with a low DC disconnect feature to disconnect the UPS from battery when this level is reached.

This is a standard factor on all UPS systems, but if not, this feature should be requested.

D. Battery Safety Precautions

Batteries can provide many years of safe, reliable service. However, the use and handling of batteries does pose some hazard, unless safety precautions are exercised. Before removing batteries from the pallet, the customer must read and become familiar with the personal safety precautions regarding battery handling. In addition, since batteries can be damaged due to incorrect handling, the customer should also read all the general equipment precautions and handling instructions.

Briefly, be aware that batteries can contain residual gas in the cells, even during shipping. Do not smoke or otherwise introduce flames, sparks or other potential sources of ignition into the battery area. Batteries are usually shipped wet, filled with sulfuric acid electrolyte for lead acid types or potassium hydroxide for nickel cadmium types. Both are caustic. Be careful to keep them upright at all times. Batteries can supply very high short circuit currents. Remove all rings and jewelry. Use only insulated tools. Keep all metal tools or metal parts which could be dropped across the battery terminals away from the batteries.

Before stationary batteries are installed, the battery room should be equipped with an emergency eye wash and the customer should become familiar with its operation. He should also have available full eye protection, rubber gloves, and apron to protect eyes and skin from contact with the sulfuric acid electrolyte. These items can be ordered with the battery, or the customer can order from his preferred source and have available before the batteries arrive.

For further information regarding batteries, refer to Selection and Sizing of Batteries for UPS Back-up, by Kenneth E. Eppich, Sales Engineer.

Section V: Start-Up Supervision

All UPS Systems which are not plug-in compatible, should be able to be installed by a qualified electrician. Further, SCI recommends that the customer purchase start-up supervision to be sure that the equipment is installed and operating properly. Severe damage could result if the equipment is installed improperly and start-up initiated. Also, even though the equipment was tested and operating properly at the factory, damage could have been sustained during shipment. Our thoroughly trained Field Service Technicians utilize procedures to detect damage or other possible malfunctions due to shipping mishandling, thus avoiding time consuming delays.

Start-up supervision will include, but not necessarily be limited to the following:

1. Inspect incoming cable to assure that they are of adequate size. Inspect the cable terminations in the unit to assure that they are properly made and are secure.
2. Inspect the inter-connections between bays to be sure that they have all been connected properly and securely.
3. Perform voltage checks on all incoming services to assure all are within specification.
4. Inspect the DC connections to assure that proper polarity has been observed.
5. Inspect bypass source input and system output on three phase units to assure that proper phase rotation has been observed.
6. Inspect battery installation, checking for cell damage, electrolyte level, inter-cell and inter-tier or step connections and proper polarity of each cell.
7. Turn on the inverter and perform system output voltage, current and frequency checks. Make any necessary adjustments to the equipment.
8. Acquaint the customer's personnel with the equipment and system operation. Explain routine maintenance of the equipment, including batteries.

SCI Field Service Technicians also provide detailed personalized training of customer's service personnel, if required, either at the time of start-up or at some other time convenient to the customer. The customer should discuss these requirements with our Field Service Manager.

Section Vi: Service And Training

SOLIDSTATE CONTROLS, INC. is dedicated to providing the most reliable Uninterruptible Power Systems available. Even as exacting as we build our equipment, we recognize that some service and repair may one day be required. With this in mind, SCI has provided for UPS maintenance by having available a strong field service team, offering service training to those customers who elect it.

SCI field service personnel are available on short notice to respond to our customers' requests for maintenance and repair. SCI maintains a complete history file on each unit which includes test data, previous service trips, and repairs. This up-to-date file can aid the field service personnel in providing even faster repair by isolating and identifying a particular problem.

As a benefit to those customers who choose to perform their own repair, SCI has a full-time service expert who, by telephone, can direct the customer's service technician through a step-by-step program of trouble-shooting and repair in order to get the customer's equipment back on-line in the shortest possible time.

SINGLE or THREE PHASE?

Although it is common for UPS larger than 10 KVA to be specified with three phase output, industrial distributed control systems rarely consist of any component that actually requires true three phase power. Particularly on smaller systems (under 50 KVA), there are some very real technical advantages to single phase distribution.

Unlike a typical building distribution system which has relatively low source impedance, an inverter is a high impedance power source. This high impedance effectively limits the amount of fault current available to clear downstream branch faults. Although under normal operating conditions most UPS clear downstream faults and short circuits by transferring the load to the low impedance bypass line via the static switch, there are operating conditions that will need the inverter to be capable of clearing a faulted branch circuit.

The most obvious of these situations would be if the bypass line were not present due to a power failure; in which case, the inverter would be operating off the battery. A not so obvious and rarely considered case would be if the inverter were out of sync with the bypass. Transfer is inhibited when out of sync to prevent an out of phase transfer from occurring. The most common cause of an out of sync condition is if the facility in question is supported by an emergency stand-by generator. If the generator is powering motor loads in addition to the UPS, the frequency will sag or overshoot anytime a load is applied or removed, resulting in an inverter out of sync condition.

When three phase output inverters are used to power single phase distribution, only one third of the inverter's total fault rating is available to clear a line to neutral fault. If a single phase inverter is used, it's entire fault rating is available to clear a line to neutral fault.

As an example, if we considered a 15 KVA application using SCI's 500% of rated (much higher than most) fault current capability, a three phase inverter would have a total of 208 amps available while a single phase inverter would be capable of 625 amps. If the inverter were at full load, these would be reduced to 166 amps and 500 amps, respectively. It would be highly unlikely that the three phase unit could clear a fast acting fuse, much less a circuit breaker, prior to current limiting. Once the inverter goes into current limit, the voltage will decrease and the entire load will be dropped.

In summary, a single phase output inverter of any size rating will stand a much better chance of clearing a branch fault than a like sized three phase inverter. Other advantages such as lower inverter initial cost and simpler distribution (no need to balance phases) greatly outweigh the minimal inconvenience and slightly higher cost of the larger wire required for single phase.

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