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2.0 SCOPE 2

2.1 This specification defines the requirements for an Uninterruptible Power Supply System (UPS) design to supply superior power to crucial electronic control loads and/or computer system loads. The UPS output power to the critical load shall maintain its integrity and provide continuous power during unpredictable fluctuations and outages of the main power source. Additionally, the UPS shall provide absolute electrical isolation from the input source.

3.0 DEFINITIONS

3.1 A complete **UPS** (Uninterruptible Power Supply) System includes a Rectifier/Charger, Static Inverter, Static Bypass Switch, Manual Bypass Switch, and Stationary Battery.

3.2 The **UPS LOAD** is the critical equipment using the reliable power from the UPS system.

3.3 The **RECTIFIER/CHARGER** is the component assembly that rectifies the incoming AC power, regulates this DC to a precise voltage level to properly "Float Charge" the battery during normal operation, and provides DC power to the Inverter.

3.4 The **INVERTER** converts the DC from the Rectifier/Charger and/or battery to the proper regulated AC voltage for the load.

3.5 The **STATIC SWITCH** is a solid state assembly which is capable of transferring the load from the Inverter to the Bypass source without interruption. It continuously senses the Inverter output voltage and the UPS load current, checking for an Inverter failure or system overload.

3.6 The **MANUAL BYPASS SWITCH** is provided to bypass the Inverter and Static Switch for maintenance purposes. In the "Bypass" position the Bypass source is connected to the load.

3.7 The **BATTERY BANK** consists of an assembly of high quality energy storage cells which are charged continuously during normal operation. It serves as the power source to the Inverter during incoming AC power outages.

4.0 GENERAL STANDARDS AND MATERIAL REQUIREMENTS

4.1 Standards

4.1.1 The UPS shall be constructed in accordance with the latest applicable standards of ANSI, IEEE, NEC, OSHA, and NEMA.

4.2 Materials and Part

4.2.1 All materials used in the construction of the UPS equipment shall be new and of high quality. Reconditioned material or parts shall not be utilized.

4.3 Enclosures

4.3.1 The UPS equipment except for the battery will be housed in a Nema 1 free-standing, dead front, ventilated enclosure. The enclosure framework will be minimum 11 gauge steel welded. All attached panels shall be 14 gauge minimum.

4.3.2 The enclosure and panels shall be cleaned, primed and coated with enamel ansi 61 gray.

4.3.3 The enclosure and interior layout will be so designed to allow all normal maintenance to be performed from the front hinged door(s).

4.3.4 Printed circuit boards and miscellaneous control components shall be mounted to be accessible from the front of the enclosure.

4.3.5 Internal panels which contain "live" heatsinks shall be of electrically insulating phenolic material. Holes shall be fabricated in the panel to allow component replacement without dismounting the heatsink.

4.3.6 Removable conduit entrance plates shall be provided for external wiring entry.

4.3.7 The enclosure(s) shall be provided with lifting eyes for lifting. Additionally, the equipment shall be shipped on pallets to allow forklift handling.

4.4 Wiring

4.4.1 All wiring to printed circuit board screw type terminals shall be labeled with the appropriate pin number identification. Each control wire connected to internal blocks on subassemblies shall be labeled and identified with the corresponding code number on the wiring schematic.

4.4.2 All wire lugs shall be of the crimp type and shall have an anti-corrosive finish.

4.4.3 Wiring being routed to hinged panels and hinged doors shall be of the multi-stranded highly flexible type.

4.5 Components

4.5.1 UL listed components shall be used wherever available.

4.5.2 All active components shall be of the static type.

4.5.3 All semiconductors shall be hermetically sealed.

4.5.4 Power semiconductors shall operate at 60% or less of their rated value.

4.5.5 Relays shall be equipped with dust covers.

4.6 Grounding

4.6.1 The UPS output power neutral shall be isolated from the UPS chassis. The neutral is to be grounded at the facility where it is installed. A ground terminal shall be provided for grounding the enclosure.

4.7 Surge Protection

4.7.1 Metal Oxide Varistor Surge Suppressors shall be installed in the UPS to protect the components from primary AC input surges.

4.8 Noise

4.8.1 Audible noise generated by the UPS should not exceed a sound pressure level of 72 dba at a distance of 6 ft.

4.9 Labeling

4.9.1 All external components shall be identified with engraved nameplates fastened with aluminum rivets. All internal control components shall be identified with the circuit designation corresponding to the system schematic.

5.0 SYSTEM CONFIGURATION AND OPERATION

5.1 Configuration

5.1.1 The system configuration shall be a true "On Line" type. The load shall normally be fed by the Inverter through the Static Switch. The system shall not be considered "On Line" by being configured with a power conditioning transformer or line filtering component which normally feeds the load and switches to the Inverter when the normal AC power source fails.

5.2 Modes of Operation

5.2.1 Normal Operation

The Rectifier/Charger shall receive power from the primary AC power source converting the AC to DC to provide DC input power to the Inverter and to float charge the battery. The load shall be continuously supplied by the Inverter through the Static Switch.

5.2.2 Emergency Operation

When the primary AC power source fails, the Inverter shall begin to use energy from the Battery rather than the Rectifier/Charger. There shall be no load switching required.

5.2.3 Recharge

When the primary AC power source returns after an outage, the Rectifier/Charger shall provide power to the Inverter while simultaneously recharging the depleted battery. This shall occur automatically with no interruption to the critical load.

5.2.4 Static Bypass

In the event of a UPS malfunction, a Static Bypass Switch shall ensure the continuity of power to the critical load by automatically transferring the load to an alternate AC source within 4 ms. The following conditions shall cause a Static Switch transfer to the alternate source:

A. Battery depleted to its discharged point.

B. UPS overload

C. Inverter output voltage varies beyond specified limits.

D. Manual initiation by a control push button.

E. Inverter off line manually or because of component failure.

5.2.4.1 Automatic/Manual Retransfer

There shall be an Automatic/Manual Retransfer select switch. In "Automatic", the event of a UPS overload shall cause the

load to transfer to the alternate source. The Static Switch shall latch to the alternate source and will not attempt to retransfer back to the Inverter while the overload exists. When the fault condition ceases to exist, a time delay shall elapse, then the Inverter shall again assume the load and the alternate source shall be disconnected from the load without an interruption in power to the load. The length of the time delay shall be user selectable. The selections available shall be approximately 10, 30, 60, and 120 seconds.

When the Automatic/Manual Retransfer Select Switch is in the "Manual" position, a fault condition shall cause the Static Switch to latch to the alternate source. Manual initiation of a control push button shall be required to shift the load back to the Inverter.

Regardless of the position of the Automatic/ Manual Retransfer Switch, should Bypass power fail, the Static Switch will retransfer the load to the Inverter.

5.2.5 Manual Maintenance Bypass Switch

A Manual Bypass Switch shall be provided on the front of the UPS cabinet. It shall be a "make before break" type to allow the critical load to be transferred to the alternate source while simultaneously isolating the Inverter and Static Switch.

5.3 System Data to be Specified

5.3.1 Input to UPS

Nominal Voltage_____VAC

___1 Ph. 2 wire, or ___3 Ph. 3 wire

Frequency __60 HZ., or __50 HZ.

5.3.2 Battery standby time for fully loaded UPS

___Minutes, or ___Hours

5.3.3 Output of UPS

Nominal Voltage_____VAC

___1 Ph. 2 wire, or ___3 Ph. 4 wire

Frequency __60 HZ., or __50 HZ. to be sync'd to the alternate source line.

KVA Rating @ .8 PF ___KVA

5.3.4 Alternate Source Input

If other than the UPS output, a transformer is required to convert to the proper voltage and/or three phase configuration.

Primary Voltage _____VAC, ___Ph., ___wire

6.0 DETAILED EQUIPMENT SPECIFICATIONS

6.1 Rectifier/Charger

6.1.1 Input Power

The nominal input voltage, number of phases and wires, and frequency shall be in accordance with the data specified in section 5.3.1. The output performance specifications shall be maintained while tolerating the following input variations.

Voltage +/- 10% of nominal

Frequency +/- 5% of nominal

6.1.2 Transformer Isolation

The Rectifier Bridge shall be completely isolated from the input power line by a step-down isolating transformer. A non-isolating auto-transformer shall not be acceptable.

6.1.3 Input/Output Protection

Both the primary of the input isolation transformer and the Charger/Rectifier output shall be protected with a thermal/magnetic circuit breaker. The breakers shall be accessible for operation from the outside of the UPS enclosure.

6.1.4 Regulation

The DC Voltage output shall be maintained to within +/- 1% from no load to full load with an acceptable AC input as defined in section 6.1.1.

6.1.5 Ripple

To prevent damage to the battery and to provide clean DC power to the

Inverter, the output of the Rectifier shall utilize an LC type filter to limit the ripple current to 2% RMS.

6.1.6 Power Factor

The typical input power factor shall be 0.9 lagging with nominal AC input at rated load. It shall be minimum 0.70 PF with maximum AC input voltage level from no load to full load.

6.1.7 Efficiency

When operated at their minimum AC input voltage, typical efficiencies for a Charger/Rectifier intended for use with a 120VDC nominal battery bank shall be as indicated below:

Single Phase/Dual Thyristors 90% @ 130VDC

Three Phase/Three Thyristors 92%

Three Phase/Six Thyristors 95%

6.1.8 Current Limit

The Charger/Rectifier shall be capable of operating into an absolute short circuit continuously without operating any of its protective devices. The current limit shall be achieved by electronic control and shall be adjustable from 100% to 125% of the nominal charger current rating. It shall be factory set at 110%

6.1.9 Soft Start

The control circuitry shall be designed to cause the Charger/Rectifier to assume the DC load gradually over approximately 10 seconds on initial AC power energization. Initial power input surges of 5 seconds or less shall not be allowed to affect the charger regulating circuitry.

6.1.10 Capacity

The Rectifier/Charger shall have the capacity to supply the fully loaded Inverter while simultaneously recharging the depleted battery within 10 times the specified battery standby time.

6.1.11 Input Harmonics

The input voltage harmonic feedback shall not exceed 10% with nominal input voltage and rated load.

Charger AC Input Current Harmonics are a function of Pulse Order. Charger harmonics can cause problems with upstream transformers and electronic equipment on the same AC bus. This subject is covered in great detail in IEEE standard 519. The chart below gives typical AC input harmonic current and output ripple voltage. CPI recommend that reduces harmonics be considered as a requirement for large chargers. Alternate Pulse Order chargers can be proposed on request.

INPUT AC PHASES	CHARGER PULSE	AC INPUT HARMONICS	DC RIPPLE WITH BATTERY
1ϕ	2Pulse	70%	2%
3ϕ	6Pulse	>25%	2%
3ϕ	12Pulse	15%	0.0025%
3ϕ	18Pulse	08%	0.0008%

6.1.12 Float and Equalize Adjustments

A Float and Equalize Adjustment Potentiometer shall be included with a Float/Equalize selector switch. The Float adjustment range shall be +/- 15% of the battery nominal voltage and the equalize adjustment range from nominal to + 20%.

An optional Equalize Timer may be provided for automatic or manually initiated timed equalizing periods.

6.2 Static Inverter

6.2.1 Input

The Inverter shall be capable of operating with an input voltage range of -12.5/+16.7% of the nominal battery voltage while providing full rated power.

6.2.2 Output

The nominal output voltage shall be in accordance with section 5.3.3.

6.2.3 Voltage Regulation

Voltage regulation shall be achieved with both magnetic power control, and electronic control of phase placement for three phase Inverters.

6.2.3.1 Steady State Regulation

The steady state static regulation shall not exceed +/-2% line to neutral or line to line (3 Ph. Inverters) for the following conditions:

A. No load to full load rating as specified in section 5.3.3.
B. DC input voltage variation within the levels of section 6.2.1.
C. For 3 Ph. Inverters; Any 3 phase line to line and/or line to neutral load combination from balanced to 100% load unbalance.

6.2.3.2 Transient Response/Dynamic Regulation

When load changes are made via the Static Switch, the regulation shall not exceed +/-18% of the steady state value with full recovery to within +/-2% of the steady state in 50 ms or less for any step load change up to 100% load transfer. Magnetic power control shall limit an "overshoot" of output voltage with a step load removal up to 100%.

6.2.4 Phase Displacement

Phase displacement for three phase Inverters shall be maintained to 120 degrees +/- 1 degree with any three phase load and/or combination of unbalanced single phase line to neutral loading up to 100% load unbalance.

6.2.5 Overload Ratings

The Inverter shall limit the output to a maximum of 200% of it's rating without sustaining damage in the event of a load fault. For overloads of 125% or higher, the Static Switch shall transfer and latch the load to the alternate source if it is available. If the alternate source is not available, the Inverter shall supply the following overloads without sustaining damage:

A. 125% continuous
B. 150% for 30 seconds
C. 200% for 10 cycles

6.2.6 Frequency Regulation and Synchronization

When the alternate source frequency is within +/- 1 hertz of the nominal frequency, the Inverter shall be synchronized and phase locked to the alternate source. If the alternate source fails or deviates beyond +/- 1 hertz, the Inverter shall revert to a free running mode while maintaining a frequency regulation of +/- .01%.

When the alternate source is initialized or the frequency returns to the acceptable range, the Inverter shall resychronize at a maximum slew rate of one hertz per second.

An "In Sync" LED indicator shall be provided to indicate when the Inverter is synchronized with the alternate source.

6.2.7 Harmonic Distortion

At full load, the voltage harmonic distortion shall not exceed 3% for any single harmonic, or 5% total.

6.2.8 Input/Output Protection

Both the Inverter DC input and the AC output shall each be equipped with a thermal/magnetic circuit breaker for operation and protection. They shall be accessible for manual operation from the outside of the UPS enclosure.

6.2.9 Low DC Shutdown

The Inverter shall automatically shut down when the battery end voltage is reached. The critical load shall transfer to the alternate source if it is available.

6.3 Static Bypass Switch

The Static Switch shall be designed to normally connect the Inverter output to the critical load. The load shall be transferred to the alternate source when a fault condition occurs or upon manual initiation.

6.3.1 Automatic Transfer to Alternate

The following conditions shall cause the Static Switch to transfer the load to the alternate source.

A. Battery depleted to the discharged point.

B. UPS output overload

C. Manual initiation by a control push button.

D. Inverter output voltage deviates below 12% of nominal.

E. Inverter off line manually or because of component failure.

6.3.2 Retransfer to Inverter

There shall be a select switch for "Automatic" or "Manual" Retransfer initiation. This shall be selectable on the Static Switch control board.

6.3.2.1 Automatic Retransfer Position:

The Static Switch shall automatically retransfer back to the Inverter without manual intervention upon the return of normal Inverter voltage or the load reducing to a normal level after one of these conditions has caused a transfer to the alternate source.

If the transfer occurred due to a manual initiation or an Inverter shutdown due to a component failure, the Static Switch shall latch to the alternate source and will require manual intervention to restore the system to normal. On SCR forced commutation devices, the inverter shall shut down and the Static Switch shall also latch to the Bypass source when a depleted battery condition is detected.

Before an automatic retransfer occurs, a selectable time delay shall expire. This shall be selectable by dip switches on the control board. The selections shall be a range of 10 seconds to 2 minutes.

6.3.2.2 Manual Retransfer Position:

The Static Switch shall latch to the alternate source on the occurrence of any of the conditions listed in 6.3.1. Retransfer back to the Inverter shall require manual initiation of a control push button.

6.3.2.3 Switch Conditions

When either an automatic or manual load transfer to the inverter is made, control logic shall dictate precise points of the waveform where the inverter pole is triggered on, and where the Bypass is turned off. This logic shall prevent the

inverter from being loaded at random points, thus reducing voltage sags and overshoots beyond +/- 18% for loads up to 100%.

6.3.3 Fail Safe Operation

6.3.3.1 In the event of an alternate source failure after a transfer to alternate has been made, the Static Switch shall immediately retransfer the load back to the Inverter.

6.3.3.2 Continuity of power to the critical load shall be ensured in the event of a failure of the Static Switch sensing circuitry. The control circuitry of the static switch shall be so designed to prevent the Inverter and alternate power switching devices from both being biased on or both being off.

6.3.4 Transfer Inhibit

6.3.4.1 A transfer in either direction shall be inhibited if the Inverter and alternate source are not in phase.

6.3.4.2 A transfer to alternate source shall be inhibited if that source is not energized.

6.3.4.3 A retransfer to Inverter shall be inhibited if the Inverter is not energized or if the load exceeds 125% of the system rating.

6.3.5 Indicators

A green LED shall indicate the Static Switch is on Inverter and a red LED shall indicate that it is on alternate.

6.3.6 Manual Control Push Buttons

The following control push buttons shall be provided on front of the UPS enclosure.

6.3.6.1 An **"Immediate Retransfer to Inverter"** push button shall be provided to transfer the critical load to the Inverter when an inhibiting condition does not exist.

6.3.6.2 A **"Timed Retransfer to Inverter"** push button shall demonstrate the time delay selection when the Automatic/Manual retransfer switch is in the automatic position.

6.3.6.3 A **"Transfer to Bypass"** push button shall immediately transfer the load to the alternate source when an inhibiting condition does not exist.

6.3.7 Transfer Time

The overall transfer from Inverter to alternate shall not exceed 4 ms including sensing and transfer times. For conditions other than a bolted fault, the transfer shall be an "overlapping/no break" transfer with no interruption to the critical load. "Zero sensing" shall be utilized to trigger a high speed transfer to the alternate source in the event of a bolted fault in the load.

In addition to Zero Sensing, control logic shall be utilized to monitor the DC switching bridge of the inverter. When a deviation in the bridge occurs, a "Zero Break" load transfer shall occur prior to any degradation of the inverter output voltage.

All transfers with the control push buttons shall be overlapping with no break.

6.3.8 Load Ratings

A. 125% - Continuous
B. 150% - 30 Minutes
C. 200% - 1 Minutes
D. 1000%- 1 Cycle

6.3.9 Protection

6.3.9.1 Protection for the Inverter leg(s) shall be served by the Inverter output breaker specified in section 6.2.8.

6.3.9.2 The alternate source leg(s) shall be protected by a power fuse rated at approximately 150% of the Inverter rating.

6.4 Manual Maintenance Bypass Switch

6.4.1 A Manual Bypass Switch shall be provided on the front of the UPS cabinet to allow the load to be directly connected to the alternate source while maintenance is performed on any section of the system.

6.4.2 Type

The switch shall be a mechanical cam type with a grip handle for manual snap action rotation. The contacts shall be "make before break" in both

directions to ensure continuity of power to the critical load.

6.4.3 Configuration

The switch shall have two positions at approximately 30 degrees and 330 degrees from top center. The left position (330 deg.) shall be the normal position and labeled "Inverter." The right position (30 deg.) shall connect the alternate source to the load and labeled "Bypass." There shall be (3) normally closed and (1) normally open power contact for each power line phase of the system configured as follows:

6.4.3.1 Inverter Position

The (3) normally closed contacts shall connect the Inverter, Bypass, and output to the Static Switch.

6.4.3.2 Bypass Position

The (3) normally closed contacts shall open, completely isolating the Static Switch and Inverter from the load. The normally open contact shall close, routing the alternate source directly to the load.

6.5 Battery

An industrial stationary storage battery shall be provided to serve as the stored energy source during main power failures. The battery shall be sized for the standby time as specified in section 5.3.2.

6.5.1 Types

The battery type will depend on the standby operating requirement, installation site environment, and user preference. The types considered shall be as follows:

A. Sealed Maintenance Free Lead Calcium
B. Flooded Lead Calcium
C. Flooded Lead Antimony
D. Sealed Maintenance Free Gelled Cell
E. Sealed Maintenance Free Absorbed electrolyte
F. Nickel Cadmium

6.5.2 Life

The warranted battery life shall be a consideration for the battery choice. The warranty provided by the battery manufacturer shall be a minimum of

10 years pro-rata for sealed maintenance free types and 20 years for all flooded cells.

6.5.3 Accessories

6.5.3.1 The following accessories shall be provided for all batteries.

A. Intercell/interow connecting hardware
B. Manufacturers installation and maintenance manual

6.5.3.2 The following additional accessories shall be provided for flooded cell types.

A. Hydrometer
B. Thermometer
C. No-oxide grease for all connections

6.5.4 Rack

A rack of all steel construction shall be provided for the battery. It shall be provided with plastic insulators at all points of contact with the battery case. The rack shall be coated with an acid resistant paint. When stipulated by the installation site requirements, the rack shall be a seismic type suitable for the site earthquake zone.

6.5.5 Enclosure

In lieu of an open rack, an optional battery enclosure may be provided. The cabinet style and color shall match the UPS enclosure. Adequate ventilation shall be provided for all battery types.

6.6 Controls, Instruments, Indicators, and Alarms

6.6.1 Controls

The following controls shall be accessible from the front of the UPS enclosure.

A. Charger Power Breaker
B. Charger Output Breaker
C. Inverter Power Breaker
D. Inverter Output Breaker
E. Inverter Start Push Button (7.5KVA and larger)
F. Manual Maintenance Bypass Switch
G. "Immediate Retransfer", "Timed Retransfer", and "Transfer to Bypass" Static Switch control push buttons.

H. Float/Equalize select switch or Equalize Timer with control push buttons.

6.6.2 Instruments

All instruments shall be panel mount type with 3.5 inch scales. The accuracy shall be within 2%. For three phase Inverters, a three position phase selector switch shall be provided to allow monitoring of all three phases. The selector switch shall simultaneously switch the Inverter voltmeter and ammeter. The following points shall be monitored, each with an individual dedicated meter.

A. DC Bus
B. Charger Output Bus
C. Inverter Output Volts (Line to Line for 3 Ph. Inverters)
D. Inverter Output Amps

6.6.3 Indicators

Illuminating indicators shall be provided and arranged on a system mimic bus on the front of the UPS enclosure. They shall be replaceable from the front of the enclosure. The following conditions shall be indicated:

A. AC input failure
B. Low DC volts
C. Inverter Failure
D. Static Switch on Inverter
E. Static Switch on alternate
F. In sync.

6.6.4 Alarms

A form C relay contact shall be provided for customer connection for each of the following alarm conditions.

A. AC input failure
B. On Equalize
C. Low DC volts
D. Inverter Failure
E. Static Switch transferred to alternate

7.0 EQUIPMENT ENVIRONMENT

7.1 Temperature

Operating: Between 0 and 40 degrees celsius

Nonoperating: Between -20 and 70 degrees celsius

7.2 Humidity

Operating and nonoperating: From 0 to 95% noncondensing.

8.0 TESTING

8.1 A detailed test procedure shall be followed for a complete functional checkout of the system to verify compliance with this specification. All data shall be made available for the customer. The UPS unit shall be subjected to a minimum 24 hour burn in prior to shipment.

The standard test procedure of the manufacturer shall be followed and shall include the following tests as a minimum:

8.1.1 Charger DC voltage regulation from no load to full load

8.1.2 Check Charger current limiting ability by applying a minimum 150% load

8.1.3 Inverter AC output voltage regulation from no load to full load. Three phase Inverters shall be subjected to maximum 100% load phase unbalance condition to verify compliance of the required voltage regulation

8.1.4 Low DC shutdown of Inverter

8.1.5 Phase difference between Inverter and alternate source while synchronized

8.1.6 Observe and measure with an oscilloscope the transfer time from Inverter to the alternate source with a simulation of Inverter fault

8.1.7 All functions of the static switch including the following:

A. Automatic and manual transfers in both directions
B. Lockout ability for out of phase and system overload conditions
C. Transfer to alternate source due to a system overload
D. Retransfer back to Inverter due to an alternate source failure after a transfer had been made to alternate.

8.1.8 Observe with an oscilloscope load transfers with the Manual Bypass Switch to ensure "Make Before Break" action.

8.1.9 Operation of all alarm indicators and contacts for remote use.

9.0 Warranty

9.1 UPS Equipment

The warranty period shall be for a period of one year after initial field startup not to exceed 18 months from the ship date. Coverage shall include all parts and labor at the job site. See separate LIMITED WARRANTY for a complete warranty description.

9.2 Battery

The battery warranty shall be provided by the battery manufacturer per a pro-rata schedule for the particular battery type selected.

10.0 START UP SERVICE

10.1 A factory trained technician shall be available for system start up assistance and commissioning. Service rates shall apply as proposed at time of the equipment purchase order.