

APC Smart-UPS VT, w/Parallel Operation

Guide Specification for 10kVA to 40kVA 3×400/400-230V Solutions Uninterrupted Power Supply

Part 1 GENERAL

1.1. SUMMARY

- A. This specification describes a three-phase, on-line, continuous operation, solid-state uninterruptible power supply (UPS) with the option to run in parallel with identical units. The UPS shall operate as an active power control system, working in conjunction with the building electrical system to provide power conditioning and on-line power protection for the critical loads.

1.2. DESCRIPTION

- A. The UPS shall consist of the following easy to repair modular rectifier/inverter sections and easy to install internal and external modular battery units.
- B. The UPS shall be provided with separate feeds for rectifier/inverter section and the static bypass switch.
- C. Modes of operation: The UPS shall operate as an on-line system in the following modes:
 - i. *Normal*: The inverter and the rectifier shall operate in an on-line manner to continuously regulate the power to the critical load. The rectifier shall derive power from the AC input source and supply DC power to float charge the battery.
 - ii. *Battery*: Upon failure of the AC input source, the critical load shall continue being supplied by the main inverter without any switching. The inverter shall obtain its power from the battery. There shall be no interruption in power to the critical load upon failure or restoration of the AC input source.
 - iii. *Recharge*: Upon restoration of the AC input source, the UPS shall simultaneously recharge the battery and regulate the power to the critical load.

- iv. **Static Bypass:** The static bypass switch shall be used for transferring the critical load to input supply without interruption. Automatic re-transfer to normal operation shall also be accomplished with no interruption in power to the critical load. The static bypass switch shall be fully rated and shall be capable of manual operation. The UPS shall be able to recharge the batteries while supplying full power to the load via the static bypass switch.
 - v. **Internal maintenance bypass switch:** The UPS shall be provided with an internal manual bypass switch for supplying the load directly from the mains supply, while the UPS is taken out for maintenance. The switch should be removable when the individual UPS unit has to run in parallel with other units.
 - vi. **External Maintenance Bypass Panel (MBP):** The external Maintenance Bypass Panel shall be used for paralleling of multiple UPS units (optional for single UPS unit) to supply the load directly from the mains supply, if the UPS system has to undergo maintenance or service. An UPS input, output, common output and bypass breaker shall be housed in the same low-voltage assembly. The manual bypass breaker must be monitored by each UPS via an auxiliary contact. The Maintenance Bypass Panel must be housed in a wall mounted low-voltage assembly and painted in a black colour that complements the appearance of the UPS.
- D. The UPS shall be provided with RS-232 signalling and WEB/SNMP integration. This system must provide a means for logging and alarming of all monitored points plus email notification.
 - E. The UPS shall have nominal voltage of 3×400/230V (adjustable for 3×380/220V, 3×415/240V), 50Hz, L1,L2,L3,N,PE.
 - F. The UPS will be capable of paralleling up to max 4 like kVA and type UPS systems for capacity.
 - G. The UPS shall be compatible with all types of data centres, data rooms and facilities. Dedicated service to one specific environment shall not be acceptable.

1.3. STANDARDS

- | | |
|------------------------------|-------------------------|
| A. Directives for CE marking | 89/336/EDC
73/237EEC |
| B. Safety | EN/IEC62040-1-1 |
| C. Emissions | EN50091-2 / IEC62040-2 |
| D. Performance | EN/IEC62040-3 |

E. Electro Static Discharge performance criteria A	EN/IEC 61000-4-2 level 3,
F. Continuous Electromagnetic Susceptibility	EN/IEC 61000-4-3 level 2, performance criteria A
G. Electrical Fast Transient Compatibility	EN/IEC 61000-4-4 level 2, performance criteria A
H. AC Surge Susceptibility	EN/IEC 61000-4-5 Level 3 criteria A

1.4. CLASSIFICATION

- A. Classification according to EN/IEC 62040-3: VFI-SS-112

1.5. SUBMITTALS

A. Proposal Submittals

- i. Bid system bill of materials
- ii. Product catalogue sheets or equipment brochures
- iii. Product guide specifications
- iv. System single-line operation diagram
- v. Floor layout
- vi. Capacity data
- vii. Piping connection drawing
- viii. Installation guide
- ix. Drawings for requested optional accessories

B. Delivery Submittals

- i. Installation manual, which includes instructions for storage, handling, examination, preparation, installation, and start-up of all systems.
- ii. User manual, which includes operating instructions.
- iii. As built equipment drawings.

1.6. QUALIFICATIONS

- A. Manufacturer experience: The manufacturer shall have a minimum of 20 years experience in the design, manufacture, and testing of UPS and cooling systems.
- B. ISO 9001 Certification: The manufacturer shall be ISO 9001 & 14001 certified. Certification assures that the vendor's quality control & environmental measures have been certified by an accredited registrar and meet internationally recognized standards.

1.7. ENVIRONMENTAL REQUIREMENTS

- A. Storage ambient temperature: -50°C to 40°C
- B. Operating ambient temperature: 0°C to 40°C . 15°C to 25°C is ideal for batteries (above the battery lifetime is reduced).
- C. Relative humidity: 0 to 95%, non-condensing.
- D. Storage elevation: 0 to 15000m.
- E. Operating altitude with no de-rating: 0 to 1000m feet above sea level.

1.8. MANUFACTURER

- A. Provide American Power Conversion: APC Smart-UPS VT system. No substitutes will be considered.

OR

- B. American Power Conversion: APC Smart-UPS VT or approved equal. However, if a brand other than APC is proposed, the decision of the Engineer shall be final and a “differentiation report” must be submitted. This report shall address each paragraph of the specification individually and list any and all differences from what is specified. If there are no differences, provide a report so stating. If, after installation, omitted differences are found, the Contractor shall correct differences to the satisfaction of the Owner and Engineer or unsatisfactory equipment shall be removed and equipment acceptable to the Owner and Engineer shall be installed at no additional cost to the project.

Part 2 PRODUCT

2.1. STATIC UPS

A. GENERAL

- i. The UPS shall be housed in a free standing enclosure. The enclosure shall be designed to blend into an IT environment. The cabinet shall be equipped for fork truck lifting. The UPS cabinet shall be painted with the manufacturer’s standard colour, black. All service and installation access shall be from the front and top
- ii. The UPS should be able to line up and match and bolt together with other similar kVA and type UPS’ to have the appearance of one entity.
- iii. The UPS shall be in a self contained cabinet and comprise 10kVA, 15kVA, 20kVA, 30kVA or 40kVA power section; Bypass Static Switch; Battery for standard run time and interface LCD display all mounted in a separate cabinet. The UPS shall permit user installable and removable battery units.

The power section shall be of the Double Conversion On-Line topology with power factor corrected input.

1. The UPS shall be sized for _____ kVA and _____ kW load at power factor 0.8.
 2. The UPS battery shall be sized for _____ at a power factor of _____ for _____ minutes.
- iv. The UPS shall have a short circuit withstand capability of 30kA

B. SYSTEM INPUT

- i. Nominal Input voltage rating: 3×400/230V (adjustable for 3×380/220V or 3×415/240V)
- ii. Input Voltage range: 304-477V
- iii. Earthing principle: [TN-S] [TT] or [IT].
- iv. Input frequency: 40-70 Hz (auto sensing)
- v. Input power factor: 0.98
- vi. Magnetizing inrush current: NONE, if optional input isolating transformer is installed then 500% of nominal input current for less than one cycle
- vii. Input current distortion with no additional filters.
- viii. < 5% THD at 100% load
- ix. Power walk-in/Soft-Start: Shall be linear from 0 to 100% of the load over a 15-second period

C. SYSTEM OUTPUT

- i. Nominal Output voltage rating: 3×400/230V.
- ii. Earthing principle: [TN-S] [TT] or [IT].
- iii. Output voltage regulation for steady state and transient variations (at default parameter settings):
 1. ± 1% steady state for a static 100% balanced load.
 2. ± 1% steady state for a static 100% unbalanced load.
 3. ± 5% for a 0 to 100% load step.
- iv. Max. Voltage transient recovery time: 50 milliseconds to nominal.
- v. Output frequency regulation:
 1. Synchronized to mains over the range of 47-53Hz or 57-63Hz in normal operation
 2. 50 Hz ± 0.1 Hz in battery operation.
- vi. Output voltage harmonic distortion:
 1. <2% THD maximum and 1% single harmonic for a 100% linear load
 2. <5% THD maximum for a 100% non-linear load
- vii. Overload capability:
 1. 150% for 1 minute in normal operation
 2. 125% for 10 minutes in normal operation
 3. 110% continuous in bypass operation

4. 800% for 500 milliseconds in bypass operation
- viii. Phase displacement:
 1. 20 degrees \pm 1 degree for balanced load.
 2. 20 degrees \pm 1 degree for 50% unbalanced load.
 3. 20 degrees \pm 3 degrees for 100% unbalanced load.
- ix. Output Power Factor Rating: For loads exhibiting a power factor of 0.5 leading to 0.5 lagging, no de-rating of the UPS shall be required.
- x. Short circuit withstand: The UPS must withstand a bolted-fault short circuit on the output without damage to the UPS module.
- xi. System AC-to-AC efficiency >95.3% for loads greater than 100% of system load.
- xii. System AC-to-AC efficiency >94% for loads greater than 50% of system load.
- xiii. Acoustical noise: dB(A) of noise, typically, measured at 1 meter from the operator surface:
 1. < 54dBA - 10kVA – 15kVA
 2. < 58dBA - 20kVA – 40kVA

D. COMPONENTS

- i. Rectifier
 1. Each UPS power module shall include an active power factor corrected, Insulated Gated Bipolar Transistor (IGBT) rectifier.
 2. DC buss voltage shall be \pm 192Vdc nominal.
 3. The battery charging shall keep the DC bus float voltage of \pm 220v, \pm 1%
 4. The DC buss voltage shall be compensated against temperature variations (Battery Temperature Compensation) to always maintain optimal battery float charging voltage for temperature excursions above or below 25°C. Temperature compensation rate shall be 320mV/°C for ambient temperatures > 20°C and 0mV/°C for ambient temperatures < 20°C.
 5. DC ripple voltage shall be less than \pm 1% of nominal with no battery connected.
 6. Input power factor shall be 0.98 lagging at 100% load with out the use of passive filters. Rectifier shall employ electronic wave-form control technology to maintain the current sinusoidal.
 7. Pulse Width Modulation (PWM) current control shall be used. Digital Signal Processors (DSP) shall be used for all monitoring and control tasks. Analogue control is not acceptable.
 8. Reflected input current Total Harmonic Distortion (THD) shall not exceed 5% at 100% load.
 9. Input voltage window: 304-477V.
 10. Typical batteries recharge time per IEEE 485.
- ii. Batteries

1. Standard battery technology shall be Valve Regulated Lead Acid (VRLA).
2. Batteries shall be housed in the same rack as the power section. Batteries shall be modular on pull out shelves for quick replacement and servicing.
3. Battery voltage shall be Battery Temperature Compensated as outlined in the rectifier section above.
4. End of discharge: $\pm 160\text{Vdc}$.
5. For longer runtimes, external battery frames in the same design should be offered.
6. Battery Charge Current Limit: The UPS shall be capable of limiting the energy sourced from the mains for purposes of battery charging. As a default setting, the battery charge energy will be set to 100% of its nominal value. When signalled by a dry contact, (such as from an emergency generator) the UPS shall be capable of limiting the battery charge energy taken from the mains. This shall take place in user selectable increments of 75%, 50%, 25%, 10% and 0% of the nominal charge power. The selection shall be made from the UPS front panel display/control unit.
7. The battery charging circuit shall remain active when in Static Bypass and in Normal Operation.

iii. Inverter

1. The inverter shall consist of fast switching IGBT power module.
2. Inverter shall be PWM controlled using DSP logic. Analogue control shall not be acceptable.
3. The inverter modules shall be rated for an output power factor at 0.8.
4. Nominal output voltage shall be $3 \times 400/230\text{V}$ and adjustable for $3 \times 380/220\text{V}$ or $3 \times 415/240\text{V}$, 50Hz, L1,L2,L3,N,PE.
5. Efficiency of each module at full load: Not less than
 - 10kVA 94.7%
 - 15kVA 94.7%
 - 20kVA 94.7%
 - 30kVA 94.5%
 - 40kVA 94.8%
6. Output Voltage Total Harmonic Distortion at full load:
 - Less than 2% for 100% resistive load.
 - Less than 5% for computer load as defined by EN50091-3/IEC 62040-3.
7. Output voltage regulation
 - Static: Less than 1% at full linear load.
 - Dynamic: 5% at 100% step load.
8. Output frequency: 50Hz free running.
9. Crest factor: Unlimited but regulates it down to 2.7.
10. Remote Emergency Power Off (EPO) shall be standard (wall switch and wiring shall be provided by the electrical contractor).

iv. Static Bypass Switch

1. The static switch shall consist of fully rated Silicon Controlled Rectifiers (SCRs). Part rated SCRs with a wrap around contactor are not acceptable.
2. The static bypass switch shall automatically transfer the critical load to bypass input supply without interruption after the logic senses one of the following conditions:
 - Inverter overload beyond rating.
 - Battery runtime expired and bypass available.
 - Inverter failure.
 - Fatal error in control system.
3. The static bypass switch shall automatically retransfer from bypass to the inverter, when one of the following conditions occurs:
 - After an instantaneous overload-induced transfer has occurred and the load current has returned to less than 100% of the system rating.
 - The inverter is active (on).
4. The static bypass switch shall be equipped with a manual means of transferring the load to bypass and back to inverter.
5. If more than 10 transfers from and to inverter occur in a 10 minutes period, the load shall be locked on static bypass. An alarm communicating this condition shall be annunciated.

E. MECHANICAL

i. SUVT

1. The UPS power section, Static Bypass Switch, internal manual bypass switch and the VRLA batteries shall be housed in a free standing enclosure in a matching black colour having the following specifications:
 - Colour finish. Black
 - Dead front construction
 - Caster fitted for mobility. Levelling feet shall be supplied as standard.
 - The cable entry shall be from the bottom on the back of the UPS.
 - The SUVT UPS enclosure shall meet an ingress level of min. IP20.

ii. UPS module dimensions: Height×Width×Depth

[Choose one, depending on UPS kVA and required backup time:]

SUVT10KH1B2 1490×352×928

SUVT10KH2B2 1490×352×928

SUVT10KH1B4	1490×523×928
SUVT10KH2B4	1490×523×928
SUVT10KH3B4	1490×523×928
SUVT10KH4B4	1490×523×928
SUVT15KH2B2	1490×352×928
SUVT15KH2B4	1490×523×928
SUVT15KH3B4	1490×523×928
SUVT15KH4B4	1490×523×928
SUVT20KH2B2	1490×352×928
SUVT20KH2B4	1490×523×928
SUVT20KH3B4	1490×523×928
SUVT20KH4B4	1490×523×928
SUVT30KH3B4	1490×523×928
SUVT30KH4B4	1490×523×928
SUVT40KH4B4	1490×523×928

F. 2.9 DISPLAY, CONTROLS AND ALARMS

- i. A microprocessor controlled display unit shall be located on the front of the system. The display shall consist of an alphanumeric display with backlight, an alarm LED, and a keypad consisting of pushbutton switches.
- ii. The following metered data, shall be available on the alphanumeric display:
 1. Year, Month, Day, Hour, Minute, Second of occurring events
 2. Input AC Voltage
 3. Output AC voltage
 4. Output AC current
 5. Input Frequency
 6. Battery voltage
 7. Highest Internal Battery temperature
- iii. The display unit shall allow the user to display an event log of all active alarms and of the 64 most recent status and alarm events. The following minimum set of alarm conditions shall be available:
 1. Static bypass switch on
 2. EPO Active
 3. Mechanical bypass activated
 4. External bypass switch (Q3) activated
 5. Battery discharged
 6. Return from low battery
 7. Low battery
 8. Load not powered from UPS
 9. UPS in bypass
 10. Runtime calibration aborted
 11. Runtime calibration started
 12. Runtime calibration complete
 13. Battery self test aborted

14. Battery self test started
 15. Battery self test completed
 16. Number of battery modules decreased
 17. Number of battery modules increased
 18. Fan fault
 19. SBS fault
 20. System not in sync.
 21. Bypass not available, frequency/voltage out of range
 22. Mains voltage/frequency out of range
 23. Site wiring fault
 24. Low battery voltage shut down
 25. XR battery breaker or fuse open
 26. Defective battery detected
 27. Runtime is below alarm threshold
 28. Load is above alarm threshold
 29. Battery over-voltage warning
 30. Battery over-temperature warning
 31. Emergency power supply fault
 32. Output overloaded
- iv. The following controls or programming functions shall be accomplished by use of the display unit. Pushbutton membrane switches shall facilitate these operations.
1. Silence audible Alarm
 2. Set the alphanumeric display language
 3. Display or set the date and time
 4. Enable or disable the automatic restart feature
 5. Transfer critical load to and from static bypass
 6. Test battery condition on demand
 7. Set intervals for automatic battery tests
 8. Adjust set points for different alarms
 9. Program the parameters for remote shutdown.
- v. The following shall make up the UPS front panel user interface.
1. Indicating LED's
 - Load On When Green, this LED indicates the load is being supported by the UPS output
 - On Battery When Yellow, this LED indicates the UPS is running from Battery power
 - Bypass When Yellow, this LED indicates the load is being supported by static bypass/mechanical bypass
 - Fault When Red, this LED indicates there is a fault condition present in the UPS.
 2. Push Button User Controls
 - Up Arrow
 - Down Arrow
 - Help Key

- Escape Key
 - Enter Key
- vi. Potential Free (Dry) Contacts
1. The following potential free contacts shall be available on an optional relay interface board:
 - Normal Operation
 - Battery Operation
 - Bypass Operation
 - Common Fault
 - Low Battery
 - UPS Off
- vii. For purposes of remote communications with the UPS the following shall be available and contained within the UPS on a removable, “hot swappable” “smart slot” interface card:
1. RJ-45 Interface port for remote communications with a network via web browser or SNMP, or APC InfraStruXure Manager.
 2. Environmental monitoring feature, capable of locally monitoring temperature and humidity as well as one additional generic set of user determined dry contacts capable of taking an input signal from any APC or third party on/off signal, such as water detection, smoke detection, motion, or fire detection.

G. BATTERY

- i. The UPS battery shall be of modular construction made up of user replaceable, hot swappable, fused, battery modules. Each battery module shall be monitored to determine the highest battery unit temperature for use by the UPS battery diagnostic, and temperature compensated charger circuitry.
- ii. The battery blocks housed within each removable battery module shall be of the Valve Regulated Lead Acid (VRLA) type.

Part 3 ACCESSORIES

A. EXTENDED RUNTIME (XR) OPTION

- i. For purposes of extending the UPS battery runtime, external extended runtime options shall be available. The extended runtime option shall be housed in “line up and match” type enclosures and shall contain necessary hardware and cables to connect to the UPS, or between XR enclosures. Each XR enclosure shall be equipped with removable, hot swappable, battery units housed in draw-out cartridges.
- ii. The extended runtime system shall have a 250 VDC rated, thermal magnetic trip moulded case circuit breaker (MCCB). Each circuit breaker shall be equipped with shunt trip mechanisms and 1 NO/NC auxiliary contacts. The circuit breakers are to be equipped as part of a line-up-and-match type battery enclosure.

B. MAINTENANCE BYPASS PANEL (MBP)

- i. A MBP should be offered as a standard option either for single module or multi module configurations. The maintenance bypass panel shall provide power to the critical load bus from the bypass source, during times where maintenance or service of the UPS system is required. The MBP shall provide a mechanical means of complete isolation of the UPS system from the mains supply. The MBP shall be constructed in a free-standing or wall-mounted IP20 enclosure unless otherwise stated in this specification.
- ii. As a minimum, the MBP shall contain the following features and accessories:
- iii. Current limiting breakers of the appropriate size – limiting the short circuit level to max. $I_{cc} = 30 \text{ kA}$ for the system.
- iv. Minimum 1 NO/NC auxiliary contact per unit in the parallel system for the purpose of relaying status information of the manual maintenance bypass switch to the UPS.
- v. In the case of parallel operation sufficient APC CAN bus PCB's to provide adequate communications of the MBP status to the UPS system parallel control system.
- vi. CE marked according to at least EN/IEC60439.
- vii. The MBP shall be made to Form 3b
- viii. The MBP shall be made to IP2XC

C. PARALLEL OPERATION

- i. For purposes of paralleling UPS units in the event of increased capacity or redundancy, the UPS shall contain as a standard feature, the ability to parallel up to 4 modules. In this mode of operation the output voltage, output frequency, output phase angle, and output impedance of each module shall operate in uniformity to ensure correct load sharing. This control function shall not require any additional footprint and shall be an integral function of each UPS.
- ii. Multi-drop Bus Network: Communication between modules shall be connected in a multi-drop bus network comprising two parallel redundant busses so that the removal of any single cable shall not jeopardize the integrity of the parallel communication system.
- iii. Load Sharing: A load sharing circuit shall be incorporated into the parallel control circuits to ensure that under no load conditions, no circulating current exists between modules. This feature also allows each UPS to share equal amounts of the total critical load bus. Load sharing communications shall be galvanically isolated for purposes of fault tolerance between UPS modules. A UPS module's influence over load sharing shall be inhibited in any mode where the UPS inverter is not supporting its output bus.

B. SOFTWARE AND CONNECTIVITY

- i. The Ethernet Web/SNMP Adaptor shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS and UNIX "tar" formats. The SNMP interface adaptor shall be connected to the UPS via the RS232 serial port on the standard communication interface board.
- ii. Unattended Shutdown
- iii. The UPS, in conjunction with a network interface card, shall be capable of gracefully shutting down one or more operating systems during when the UPS is on reserve mode.
- iv. The UPS shall also be capable of using an RS232 port to communicate by means of serial communications to gracefully shut down one or more operating systems during an on battery situation.

C. REMOTE UPS MONITORING

- i. The following three methods of remote UPS monitoring shall be available:
 1. Web Monitoring: Remote monitoring shall be available via a web browser such as Internet Explorer.
 2. RS232 Monitoring: Remote UPS monitoring shall be possible via either RS232 or contact closure signals from the UPS.
 3. Simple Network Management Protocol (SNMP): Remote UPS Monitoring shall be possible through a standard MIB II compliant platform.

D. SOFTWARE COMPATIBILITY

- i. The UPS manufacturer shall have available software to support graceful shutdown and or remote monitoring for the following systems:
 - a. Microsoft Windows 95/98/XP
 - b. Microsoft Windows NT 4.0 SP6/2000
 - c. OS/2
 - d. Netware 3.2 – 5.1
 - e. MAC OS 9.04, 9.22, 10
 - g. Digital Unix/True 64
 - h. SGI 6.0-6.5
 - j. SCO UNIX
 - k. SVR4 2.3, 2.41
 - m. SCO Unix Ware 7.0 - 7.11
 - n. SUN Solaris 2.6-2.8
 - o. SUN OS 4.13, 4.14
 - p. IBM AIX 4.3x-4.33g, 5.1
 - q. HP-UX 9.x-11.i

Part 4 EXECUTION

A. FACTORY ASSISTED START-UP

If a factory assisted UPS start-up is requested, factory trained service personnel shall perform the following inspections, test procedures, and on-site training:

- i. Visual Inspection:
 - Inspect equipment for signs of damage.
 - Verify installation per manufacturer's instructions.
 - Inspect cabinets for foreign objects.
 - Inspect Battery Units.
 - Inspect Power Module(s).
- ii. Mechanical Inspection:
 - Check all UPS and external maintenance bypass cabinet internal power wiring connections.
 - Check all UPS and external maintenance bypass cabinet terminal screws, nuts, and/or spade lugs for tightness.
- iii. Electrical Inspection:
 - Verify correct input and bypass voltage.
 - Verify correct phase rotation of all mains connections.
 - Verify correct UPS control wiring and terminations.
 - Verify voltage of all battery modules.
 - Verify neutral and ground conductors are properly landed.
 - Inspect external maintenance bypass switch for proper terminations and phasing.
- iv. Site Testing:
 - Ensure proper system start-up.
 - Verify proper firmware control functions.
 - Verify proper firmware bypass operation.
 - Verify proper maintenance bypass switch operation.
 - Verify system set points.
 - Verify proper inverter operation and regulation circuits.
 - Simulate utility power failure.
 - Verify proper charger operation.
 - Document, sign, and date all test results.
- v. On-Site Operational Training:

During the factory assisted start-up, operational training for site personnel shall include

- key pad operation
- LED indicators
- start-up and shutdown procedures

- Maintenance Bypass Panel operation
- Battery breaker operation
- Alarm information.

4.2 MANUFACTURER FIELD SERVICE

- i. Worldwide service: The UPS manufacturer shall have a worldwide service organization available, consisting of factory trained field service personnel to perform start-up, preventative maintenance, and service of the UPS system and power equipment. The service organization shall offer 24 hours a day, 7 days a week, 365 days a year service support.
- ii. Replacement parts: Parts shall be available through the worldwide service organization 24 hours a day, 7 days a week, and 365 days a year. The worldwide service organization shall be capable of shipping parts within 4 working hours or on the next available flight, so that the parts may be delivered to the customer site within 24 hours.

4.3 MAINTENANCE CONTRACTS

- i. A complete offering of preventative and full service maintenance contracts for the UPS system and the battery system shall be available. All contract work shall be performed by APC factory trained service personnel.

4.4 TRAINING

- i. UPS service training workshop: A UPS service training workshop shall be available from the UPS manufacturer. The service training workshop shall include a combination of lecture and practical instruction with hands-on laboratory sessions. The service training workshop shall include instruction about safety procedures, UPS operational theory, sub-assembly identification and operation, system controls and adjustment, preventative maintenance, and troubleshooting.