# APC by Schneider Electric

**APC InfraStruXure Power Distribution Unit, 60 kW and 150 kW, 208 Volt Output**
**60 kW - 150 kW UPS/PDU/Distribution**

*THIS GUIDE SPECIFICATION IS WRITTEN IN ACCORDANCE WITH THE CONSTRUCTION SPECIFICATIONS INSTITUTE (CSI) MASTERFORMAT. THIS SECTION MUST BE CAREFULLY REVIEWED AND EDITED BY THE ARCHITECT OR THE ENGINEER TO MEET THE REQUIREMENTS OF THE PROJECT. COORDINATE THIS SECTION WITH OTHER SPECIFICATION SECTIONS IN THE PROJECT MANUAL AND WITH THE DRAWINGS.*
*WHERE REFERENCE IS MADE THROUGHOUT THIS SECTION TO "PROVIDE", "INSTALL", "SUBMIT", ETC., IT SHALL MEAN THAT THE CONTRACTOR, SUBCONTRACTOR, OR CONTRACTOR OF LOWER TIER SHALL "PROVIDE", "INSTALL", SUBMIT", ETC., UNLESS OTHERWISE INDICATED.*
*THIS SECTION IS WRITTEN TO INCLUDE THE 2004 MASTERFORMAT AND THE 1995 MASTERFORMAT VERSIONS. WHERE APPLICABLE, THESE ITEMS ARE BRACKETED AND, IN EACH CASE, UNLESS OTHERWISE INDICATED, THE FIRST CHOICE APPLIES TO THE 2004 MASTERFORMAT AND THE SECOND CHOICE APPLIES TO THE 1995 MASTERFORMAT.*

## SECTION [26 26 53] [16471]

## STATIC UNINTERRUPTIBLE POWER SUPPLY POWER DISTRIBUTION UNIT

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions, [Division 01 - GENERAL REQUIREMENTS] [Division 1 - GENERAL REQUIREMENTS], and other applicable specification sections in the Project Manual apply to the work specified in this Section.

### 1.2 SUMMARY

A. **Scope:** Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for a power distribution unit (PDU) as required for the complete performance of the work, and as shown on the Drawings and as herein specified.

B. **Section Includes:** The work specified in this Section includes, but shall not be limited to, requirements for a complete power distribution system for powering IT loads.

### 1.3 REFERENCES

A. **General:** The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

B. **Electronic Industries Association (EIA):**
1. EIA 310, "Racks, Panels, and Associated Equipment" (copyrighted by EIA, ANSI approved).

C. **International Organization for Standardization (ISO):**
1. ISO 9001, "Quality Management Systems - Requirements."
2. ISO 14001, "Environmental Management Systems - Requirements With Guidance for Use."

D. **National Electrical Manufacturers Association (NEMA):**
1. NEMA TP 1, "Standard for the Labeling of Distribution Transformer Efficiency."

E. **Underwriters Laboratories, Inc. (UL):**
1. UL 60950, "Standard for Information Technology Equipment."

## 1.4 SYSTEM DESCRIPTION

*SELECT OR INSERT APPLICABLE VALUE BELOW.*

A. **Design Requirements:** The PDU shall be sized for [60 kVA] [150 kVA].

B. **System Characteristics:**
   1. **Physical:**
      a. External width dimensions shall be 23.5 inches (597 mm) for 60 kVA PDU, and 29.4 inches (747 mm) for 150 kW PDU.
      b. External depth dimensions shall be 35.4 inches (900 mm).
      c. The PDU shall have a maximum external height of 81.5 inches (2070 mm) to allow passage through a standard 7 foot (2134 mm) doorway without tipping.
   2. **Input:**
      a. AC input nominal voltage shall be [208 volts] [480 volts] [600 volts], three-phase, 3 wires, 60 hertz.

*150 kW IS AVAILABLE IN 480 VOLTS ONLY. SELECT APPLICABLE VALUE ABOVE.*

      b. The PDU shall contain a [60 kVA] [150 kVA] NEMA TP-1 compliant, energy efficient, isolation transformer, which shall be rated for modern data center IT loads.
      c. Maximum frequency range shall be 55 hertz to 65 hertz.
   3. **PDU Output:** AC nominal output voltage; 208 volts, three-phase, 4 wires, 60 hertz.
   4. **Output Distribution:**
      a. **Distribution Panels:** The PDU shall contain two 42 position output distribution panels. Each panel shall have a nominal current rating of 225 amperes, and a withstand rating of 22,000 AIC. The distribution panels shall accommodate 1 pole, 2 pole, or 3 pole snap-in or bolt-in breakers, with current capacity ranging from 10 amperes to 150 amperes. 20 ampere and 50 ampere breakers shall be used in conjunction with the below mentioned flexible distribution conducts and rack-mounted power distribution units to provide a pre-configured, tested, and UL 60950 listed branch distribution system.
      b. **Flexible Distribution Conductors:** For purposes of overhead distribution wiring of data center branch circuits, flexible conductors of either an SJO type, or TC type shall be available as a distribution means. Flexible conductors shall be equipped with NEMA cord caps and shall be agency-approved under UL 60950.

## 1.5 SUBMITTALS

A. **General:** See [Section 01 33 00 - SUBMITTAL PROCEDURES] [Section 01300 - SUBMITTALS].

B. **Product Data:** Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications. Product data shall include, but shall not be limited to, the following:
   1. As bid system bill of materials.
   2. Product catalog sheets or equipment brochures.
   3. Product guide specifications.

C. **Shop Drawings:** Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer's standard product data, including, but not limited to, the following:
   1. Installation information, including, but not limited to, weights and dimensions.
   2. Information about terminal locations for power and control connections.
   3. Drawings for requested optional accessories.

D. **Wiring Diagrams:** Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed wiring and field-installed wiring, and between components provided by the manufacturer and those provided by others.

1. Submit system single-line operation diagram.

E. **Operation and Maintenance Data:** Submit operation and maintenance data to include in operation and maintenance manuals specified in [Division 01 - GENERAL REQUIREMENTS] [Division 1 - GENERAL REQUIREMENTS], including, but not limited to, safe and correct operation of PDU functions.
1. Submit an installation manual, which shall include, but shall not be limited to, instructions for storage, handling, examination, preparation, installation, and start-up of PDU.
2. Submit an operation and maintenance manual, which shall include, but shall not be limited to, operating instructions.
3. Submit project record equipment drawings.
4. Submit manufacturer's welcome package.

## 1.6 QUALITY ASSURANCE

A. **Qualifications:**
1. **Manufacturer Qualifications:** Manufacturer shall be a firm engaged in the manufacture of PDU's of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years.
   a. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.
2. **Installer Qualifications:** Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing PDU's similar in type and scope to that required for this Project.

B. **Regulatory Requirements:** Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.
1. Work shall also be designed in accordance with the following:
   a. UL 60950.
2. Where applicable, the PDU shall also be designed in accordance with publications from the following organizations and committees:
   a. National Fire Protection Association (NFPA).
   b. National Electrical Manufacturers Association (NEMA).
   c. Occupational Safety and Health Administration (OSHA).
   d. ISO 9001.
   e. ISO 14001.

C. **Pre-Installation Conference:** Conduct pre-installation conference in accordance with [Section 01 31 19 - PROJECT MEETINGS] [Section 01200 - PROJECT MEETINGS]. Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre-installation conference shall include, but shall not be limited to, the Contractor, the Installer, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Architect/Engineer.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.

B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

## 1.8 PROJECT CONDITIONS

A. **Environmental Requirements:** Do not install PDU's until space is enclosed and weatherproof, wet work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.
   1. **Environmental:**
      a. **Storage Ambient Temperature:** -40 F (-40 °C) to 158 °F (70 °C).
      b. **Operating Ambient Temperature:** 32 °F (0 °C) to 104 °F (40 °C) (77 °F [25 °C] is ideal for most battery types).
      c. **Relative Humidity:** 0 percent to 95 percent, non-condensing.
      d. **Altitude:** Maximum installation with no derating of the UPS output shall be 10,000 feet (3048 m) above sea level.

## 1.9 WARRANTY

A. **General:** See [Section 01 77 00 - CLOSEOUT PROCEDURES] [Section 01770 - CLOSEOUT PROCEDURES].

B. **Special Warranty:** The Contractor shall warrant the work of this Section to be in accordance with the Contract Documents and free from faults and defects in materials and workmanship for period indicated below. This special warranty shall extend the one year period of limitations contained in the General Conditions. The special warranty shall be countersigned by the Installer and the manufacturer.
   1. The PDU shall be covered by a full parts and labor warranty from the manufacturer for a period of 12 months from date of installation or acceptance by the Owner or 18 months from date of shipment from the manufacturer, whichever occurs first.
   2. The battery manufacturer's warranty shall be passed through to the final Owner and shall have a minimum period of one year.

C. **Additional Owner Rights:** The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

## 1.10 MAINTENANCE

A. A complete offering of preventative and full service maintenance contracts for the PDU system and the battery system shall be available from the manufacturer. Contract work shall be performed by factory-trained service personnel.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. **Basis of Design:** Product specified is "APC InfraStruXure Power Distribution Unit, 60 kW and 150 kW, 208 Volt Output; 60 kW - 150 kW UPS/PDU/Distribution" as manufactured by APC by Schneider Electric. Items specified are to establish a standard of quality for design, function, materials, and appearance. Equivalent products by other manufacturers are acceptable. The Architect/Engineer will be the sole judge of the basis of what is equivalent.

## 2.2 DISPLAY AND CONTROLS

A. **Control Logic:** The PDU shall be controlled by a hot-swappable control module.

B. **Display Unit:** A microprocessor-controlled display unit shall be located on a hinged door in 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.

C. **Metered Data:** The following metered data shall be available on the alphanumeric display:
1. Year, month, day, hour, minute, second of occurring events.
2. Source input voltage.
3. Output AC voltage.
4. Output AC current.
5. Output kVA per phase.
6. Total output kVA.
7. Power factor per phase.
8. Input frequency.

D. **Event Log:** The display unit shall allow the Owner to display a time and date stamped log of the 64 most recent status and alarm events.

E. **Alarms:** The display unit shall allow the Owner to display a log of active alarms. The following minimum set of alarm conditions shall be available:
1. Input under voltage (phase-to-phase).
2. Input over voltage (phase-to-phase).
3. Output under voltage.
4. Output over voltage.
5. Output under current.
6. Output over current (phase).
7. Output over current (neutral).
8. Frequency out of tolerance.
9. Transformer over-temperature.

F. **Controls:** 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. Adjust set points for different alarms.
5. Map alarm dry contacts.
6. Designate input dry contacts.

G. **Potential Free (Dry) Contacts:**
1. Four dry contact inputs shall be able to be used to monitor external contact closure and shall be named by the operator through the Owner interface.
2. Four dry output contacts shall be able to be mapped by the operator through the Owner interface to any of the alarm conditions listed above.

## 2.3 ACCESSORIES

A. **Subfeed Breakers:** The PDU shall have positions shall have [zero] [one] [two], [150 amperes] [225 amperes], 3 pole, molded case circuit breakers.

*150 kVA PDU ONLY. SELECT APPLICABLE VALUES ABOVE.*

B. **Branch Circuit Monitoring:** Each pole of each circuit breaker shall be monitored, and shall report the load current drawn on each circuit breaker pole to a common infrastructure management system. Values metered by branch circuit monitoring shall be available through a web-based browsing system and shall be incorporated into the same monitoring system as the other components within this Section.

C. **Rack Mount Power Distribution Units:** For purposes of distributing power within an IT enclosure, rack mount power distribution units shall be available for installation within the IT enclosure. The rack mount power distribution units shall be capable of being installed in the back of the

accompanying enclosure to consume zero U-space in the front of the rack, and shall not require tools for installation within the rack.

1. **Input Connection:** For ease of installation, the rack mount PDU shall be connected via a twist lock connecter, and shall be capable of being fed from agency-approved flexible corded distribution wiring as described elsewhere in this Section. The input shall be capable of being served by 208 volts, three-phase [3 wires] [4 wires] from an [L21-20 type NEMA] [50A Hubblelock connector].

*MAKE APPLICABLE SELECTIONS ABOVE AND BELOW.*

   a. A hard-wired version of the product shall also be available as an option and shall be capable of being fed from a three pole [20 ampere] [50 ampere] circuit breaker.

*MAKE APPLICABLE SELECTION BELOW.*

2. **Output Connections:** The output of the rack mount PDU shall be distributed single-phase receptacles capable of supplying power to cord-connected equipment. Assuming rack mount PDU is fed from a circuit breaker with an 80 percent continuous rating, a single rack mount PDU shall be capable of distributing up to [5.7 kW] [12.5 kW] in a single rack.
3. **Options:**
   a. **Phase Metering:** The current of each input phase of the rack mount PDU shall be monitored, displayed locally on an illuminated seven segment display, and reported through a built in web/SNMP interface.
   b. **Outlet Management:** The outlets of the rack mount PDU shall have managed switched capability as an option. The current of each input phase of the rack mount PDU shall be monitored, displayed locally on an illuminated seven segment display, and reported through a built in web/SNMP interface. The web/SNMP interface shall also be used to manage and control the outlet receptacles.

D. **Rack Mount Transfer Switches:** For purposes of providing redundancy (to single corded loads) as far as the equipment rack, and the load itself, 1U rack mount transfer switches shall be available. Rack mount transfer switches shall be capable of switching a combination of single-phase and three-phase loads up to 5.7 kW. The rack mount transfer switch shall be designed to be fed from a 3 pole 20 ampere circuit breaker via a NEMA L21-20 receptacle or cord cap.

E. **Overhead Distribution:**
1. **Flexible Distribution Conductors:** For purposes of overhead distribution wiring of data center branch circuits, flexible conductors of either an SJO type, or TC type shall be available as a distribution means. Flexible conductors shall be equipped with NEMA or IEC style cord caps and shall be agency-approved under UL 60950 as part of the overall distribution system.
2. **Cable Ladder:** For purposes of routing data and power cables between rows in a data center aisle layout, cable ladders shall be available to span the gap between rows. Cable ladders shall be agency-approved under UL 60950 as part of the overall distribution system. The use of overhead cable management shall minimize the need to run data and power cable beneath a raised floor, thus minimizing potential air flow obstructions for down-flow type precision cooling solutions. This means of cable management shall also facilitate ease of installation of power and data cabling in data centers not utilizing raised floor. Optional covers shall be available for ladders as a means of adhering to local codes requiring such.
3. **Cable Trough:** For purposes of routing data and power cable along the length of a row of IT enclosures in a data center environment, cable troughs shall be available as a means of separating and housing data and power cable. Optional covers shall be available for troughs as a means of adhering to local codes requiring such. The use of overhead cable management shall minimize the need to run data and power cable beneath a raised floor, thus minimizing potential air flow obstructions for down-flow type precision cooling solutions. This means of cable management shall also facilitate ease of installation of power and data cabling in data centers not utilizing raised floor.

F. **Remote Power Panel (RPP):** For purposes of wiring convenience, remote power panels (RPP) shall be available to take a single feed from the PDU, and distribute power to the critical load. A total of two 42 pole panelboards shall be housed in the RPP to distribute a combination of single-phase and three-phase load equipment as outlined elsewhere in this Section.

1. **Branch Circuit Monitoring:** Branch circuit monitoring shall be available as outlined elsewhere in this Section.

G. **Rack Distribution Panel (RDP):** For purposes of wiring convenience, rack distribution panels (RDP) shall be available to take a single feed from the PDU, and distribute power to the critical load. One 39 pole panelboard shall be housed in the RDP to distribute a combination of single-phase and three-phase load equipment as outlined elsewhere in this Section. The RDP shall occupy the top 10U of a standard 42U, 19 inch (483 mm) wide, 42 inch (1067 mm) deep IT enclosure as outlined elsewhere in this Section.

H. **Information Technology (IT) Enclosure:** IT enclosures shall be available for housing of Owner-supplied IT equipment. Enclosures shall be listed under the same UL 60950 agency approval as other products outlined elsewhere in this Section.

1. **General Requirements:**
   a. The enclosure shall be designed to provide a secure, managed environment for computer and networking equipment.
   b. The enclosure shall conform to EIA 310 and accommodate industry standard 19 inch (483 mm) rack mount equipment.
   c. The enclosure shall be designed with four vertical posts to allow rack mount equipment installation utilizing four vertical mounting rails.
   d. The enclosure shall be available with a vertical equipment mounting space of 25U, 42U,or 47U (1U = 1.75 inch [44.45 mm]).
   e. A four post open frame configuration shall be available with 42U vertical equipment mounting space.
2. **Physical Requirements:**
   a. External width dimensions shall be 23.5 inches (597 mm) for 19 inch (483 mm) rack enclosures, and 29.4 inches (747 mm) for 23 inch (584 mm) rack enclosure.
   b. External depth dimensions shall be 35.4 inches (900 mm) or 42.2 inches (1070 mm).
   c. Rack enclosures of a 42U design shall have a maximum external height of 81.5 inches (2070 mm) to allow passage through a standard 7 foot (2134 mm) doorway without tipping.
   d. Rack enclosure shall support a dynamic load (rolling on castors) of 2000 lbs (909 kg) total weight.
   e. Rack enclosure shall also be designed and manufactured to be matching in both color and construction to the PDU enclosure to provide a uniform and consistent appearance in a data center environment.
3. **Equipment Access and Mounting:**
   a. The enclosure shall provide 25U, 42U, or 47U of equipment vertical mounting space.
   b. The vertical mounting rails shall be adjustable to allow different mounting depths.
   c. Front and rear doors of the enclosure shall be designed with quick release hinges allowing for easy detachment without the use of tools.

I. **Floor Anchor Brackets:** Floor anchor brackets shall be available to solidly connect the PDU enclosure to minimize unintended moving of the equipment.

J. **Seismic Floor Stands:** Seismic rated floor stands shall be available to take the place of supporting the PDU on a raised floor environment. Floor stands shall be available in custom heights to maintain a flush mount installation adjacent to the raised floor, and shall be designed in accordance to the equipment weight and contact points.

K. **Software and Connectivity:**

1. **Network Adaptor:** 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 RS-232 serial port on the standard communication interface board.

2. **Unattended Shutdown:**
   a. The system, 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.
   b. The system shall also be capable of using an RS-232 port to communicate by means of serial communications to gracefully shut down one or more operating systems during an on battery situation.

L. **Remote System Monitoring:** 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. **RS-232 Monitoring:** Remote UPS monitoring shall be possible via either RS-232 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.

M. **Software Compatibility:** The PDU manufacturer shall have available software to support graceful shutdown and remote monitoring for the following systems:
   1. Microsoft Windows 95/98/XP.
   2. Microsoft Windows NT 4.0 SP6/2000.
   3. OS/2.
   4. Netware 3.2 – 5.1.
   5. MAC OS 9.04, 9.22, 10.
   6. Digital Unix/True 64.
   7. SGI 6.0-6.5.
   8. SCO UNIX.
   9. SVR4 2.3, 2.41.
   10. SCO Unix Ware 7.0 - 7.11.
   11. SUN Solaris 2.6-2.8.
   12. SUN OS 4.13, 4.14.
   13. IBM AIX 4.3x-4.33g, 5.1.
   14. HP-UX 9.x-11.i.
   15. Linux.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. **Verification of Conditions:** Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Architect/Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
   1. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

### 3.2 INSTALLATION

A. **General:** Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer's written recommendations, and as indicated on the Drawings.

B. **Factory-Assisted Start-Up:** If a factory-assisted PDU start-up is requested, factory-trained service personnel shall perform the following inspections, test procedures, and on-site training:
   1. **Visual Inspection:**
      a. Inspect equipment for signs of damage.

b. Verify installation per manufacturer's instructions.
c. Inspect cabinets for foreign objects.

2. **Mechanical Inspection:**
   a. Check PDU cabinet internal control wiring connections.
   b. Check PDU internal power wiring connections.
   c. Check PDU terminal screws, nuts, and/or spade lugs for tightness.
3. **Electrical Inspection:**
   a. Verify correct input voltage.
   b. Verify correct phase rotation of mains connections.
   c. Verify neutral and ground conductors are properly landed.
4. **Site Testing:**
   a. Ensure proper system start-up.
   b. Verify proper firmware control functions.
   c. Verify proper breaker operation.
   d. Verify system set points.
   e. Document, sign, and date test results.
5. **On-Site Operational Training:** During the factory-assisted start-up, operational training for site personnel shall include, but shall not be limited to, key pad operation, LED indicators, start-up and shutdown procedures, maintenance bypass and AC disconnect operation, and alarm information.

## 3.3 FIELD QUALITY CONTROL

A. **General:** See [Section 01 45 23 - INSPECTING AND TESTING SERVICES] [Section 01410 - INSPECTING AND TESTING SERVICES].

B. **Manufacturer Field Service:**
1. **Worldwide Service:** The PDU 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 PDU system and power equipment. The service organization shall offer 24 hours a day, 7 days a week, 365 days a year service support.
2. **Replacement Parts:** Parts shall be available through the worldwide service organization 24 hours a day, 7 days a week, 365 days a year. The worldwide service organization shall be capable of shipping parts within four working hours or on the next available flight, so that the parts may be delivered to the Owner within 24 hours.

## 3.4 DEMONSTRATION

A. **General:** Provide the services of a factory-authorized service representative of the manufacturer to provide start-up service and to demonstrate and train the Owner's personnel.
1. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Train the Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventive maintenance.
3. Review data in operation and maintenance manuals with the Owner's personnel.
4. Schedule training with the Owner, through the Architect/Engineer, with at least seven day's advanced notice.

B. **PDU Training Workshop:** A PDU training workshop shall be available from the PDU manufacturer. The training workshop shall include, but shall not be limited to, a combination of lecture and practical instruction with hands-on laboratory sessions. The training workshop shall include, but shall not be limited to, instruction about safety procedures, PDU operational theory, sub-assembly identification and operation, system controls, adjustments, preventative maintenance, and troubleshooting.

## 3.5 PROTECTION

A. Provide final protection and maintain conditions in a manner acceptable to the Installer, that shall ensure that the PDU's shall be without damage at time of Substantial Completion.

**END OF SECTION**