S&C PureWave AVC™ Adaptive VAR Compensator

600 V

Instructions for Installation and Operation

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S&C ELECTRIC COMPANY

Specialists in Electric Power Switching and Protection

Instruction Sheet 656-500

September 20, 2004

Supersedes Instruction Sheet 656-500 dated 2-24-03

INTRODUCTION

Qualified Persons

⚠ WARNING

The equipment covered by this publication must be installed, operated, and maintained by qualified persons who are knowledgeable in the installation, operation, and maintenance of underground electric power distribution equipment along with the associated hazards. A qualified person is one who is trained and competent in:

- The skills and techniques necessary to distinguish exposed live parts from non-live parts of electrical equipment.
- The skills and techniques necessary to determine the proper approach distances corresponding to the voltages to which the qualified person will be exposed.
- The proper use of the special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools for working on or near exposed energized parts of electrical equipment.

These instructions are intended only for such qualified persons. They are *not* intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

Read this Instruction Sheet

Thoroughly and carefully read this instruction sheet before installing or operating your S&C PureWave AVC. Familiarize yourself with "SAFETY INFORMATION" on pages 3 and 4.

Retain this Instruction Sheet

This instruction sheet is a permanent part of your S&C PureWave AVC. Designate a location where you can easily retrieve and refer to this publication.

Proper Application

⚠ CAUTION

The equipment in this publication must be selected for a specific application. The application must be within the ratings furnished for the equipment. Ratings for this device are listed on a ratings label at the front of the unit.

Warranty

The standard warranty contained in S&C's standard conditions of sale, as set forth in Price Sheet 150, is applicable to the S&C PureWave AVC covered in this instruction sheet.

Understanding Safety-Alert Messages

There are several types of safety-alert messages which may appear throughout this instruction sheet as well as on labels attached to the PureWave AVC. Familiarize yourself with these types of messages and the importance of the various signal words, as explained below.

⚠ DANGER

"DANGER" identifies the most serious and immediate hazards which *will likely* result in serious personal injury or death if instructions, including recommended precautions, are not followed.

⚠ WARNING

"WARNING" identifies hazards or unsafe practices which *can* result in serious personal injury or death if instructions, including recommended precautions, are not followed.

⚠ CAUTION

"CAUTION" identifies hazards or unsafe practices which *can* result in minor personal injury or product or property damage if instructions, including recommended precautions, are not followed.

NOTICE

"NOTICE" identifies important procedures or requirements that *can* result in product or property damage if instructions are not followed.

Following Safety Instructions

If you do not understand any portion of this instruction sheet and need assistance, contact your nearest S&C Sales Office or S&C Authorized Distributor. Their telephone numbers are listed on S&C's website www.sandc.com. Or call S&C Headquarters at (773) 338-1000; in Canada, call S&C Electric Canada Ltd. at (416) 249-9171.

NOTICE

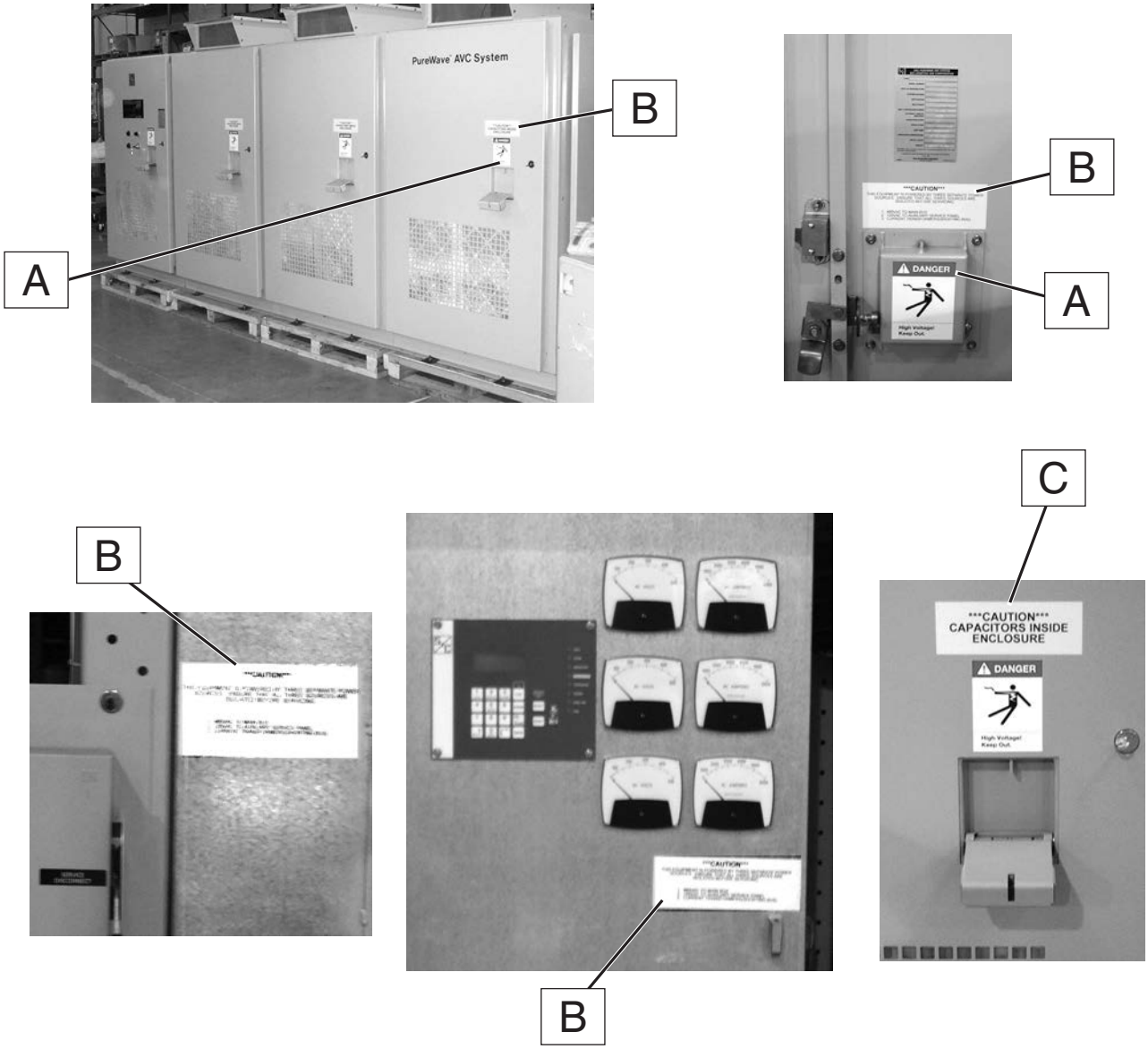
Thoroughly and carefully read this instruction sheet before installing your S&C PureWave AVC.

Replacement Instructions and Labels

If you need additional copies of this instruction sheet, contact your nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

It is important that any missing, damaged, or faded labels on the equipment be replaced immediately. Replacement labels are available by contacting your nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

Location of Safety Labels



Reorder Information for Safety Labels			
Location	**Safety-Alert Message**	**Description**	**Part Number**
A	⚠ DANGER	High Voltage! Keep Out	DD260020B001
B	⚠ CAUTION	This Equipment is Powered By Three Separate Sources	DD260021B001
C	⚠ CAUTION	Capacitors Inside Enclosure	DD260022B001

Enclosure Security

The PureWave AVC enclosure incorporates a number of features to minimize hazards to qualified persons and to the general public. Enclosures are fabricated from 11-gauge steel sheet and are free-standing and self-supporting. There are no externally removable side sheets, rear sheets, or roofs to invite removal. Access is through wide bulkhead-type doors having concealed cam-type, high-strength latches that seal the doors shut. Each door has a minimum of three concealed, extra-heavy-duty hinges with stainless-steel pins. All doors are padlockable and have top and side flanges with double 90-degree bends which overlap the door openings, adding rigidity and discouraging tampering.

Access Control

Access to internal components, controls, and meters is controlled by padlockable doors. Baffles and screens cover all vents, discouraging wire poking. Since this unit may be located in areas accessible to the general public as well as authorized but unqualified persons, care must be taken to alert such persons to the presence of high voltage within the enclosure. Therefore, do not remove any of the “Danger! High Voltage! Keep Out” signs that have been attached to the unit. Any organization altering or removing these hazard-alerting signs must assume full responsibility for such actions. Take particular care to be sure that all doors and handles are securely padlocked before leaving the unit unattended, even momentarily.

INSPECTION AND HANDLING

Packing

Each section of the PureWave AVC is shipped fastened to a wood skid. A plastic liner has been inserted underneath the section to prevent water or debris from entering the bottom during shipping or handling. The sections should be left on their skids with the liners intact until just prior to installation on the pad.

Inspection

Examine the shipment for external evidence of damage as soon after receipt as possible, preferably before removal from the carrier's conveyance. Check the bill of lading to insure that all shipping skids, crates, and containers listed thereon are present.

If there is visible loss and/or damage:

1. Notify the delivering carrier immediately.
2. Ask for a carrier inspection.
3. Note condition of shipment on all copies of the delivery receipt.
4. File a claim with the carrier.

If concealed damaged is discovered:

1. Notify the delivering carrier within 15 days of receipt of shipment.
2. Ask for a carrier inspection.
3. File a claim with the carrier.

Also notify S&C Electric Company in all instances of loss and/or damage.

Handling

⚠ WARNING

When handling a PureWave AVC with an overhead hoist, observe standard lifting practices as well as the general instructions below. **Failure to follow these precautions can result in serious personal injury or equipment damage.**

The dimensions and weight of each section of the PureWave AVC are listed in Table 1. Each section can be lifted using an overhead crane or a forklift.

If an overhead crane is to be used:

1. Use 8-foot or longer hoist slings of equal length to prevent damaging the enclosure during lifting.
2. Arrange the hoist slings so as to distribute the lifting forces equally between the eyebolts.
3. If hoist slings or chains have been provided—match the letter tag on each sling hook to the corresponding letter tag on each eye-bolt on the roof of the section. See Figures 1 and 2.
4. Make sure that the lifting hooks are completely engaged in the eyebolts before lifting the enclosure. Do not cross the slings or chains.
5. Avoid sudden starts or stops.

If a forklift is to be used, engage the forks fully across the span of the wooden pallet mounted to the base of the section.

If the PureWave AVC is to be transported through a building, place roller dollies under each corner of the section

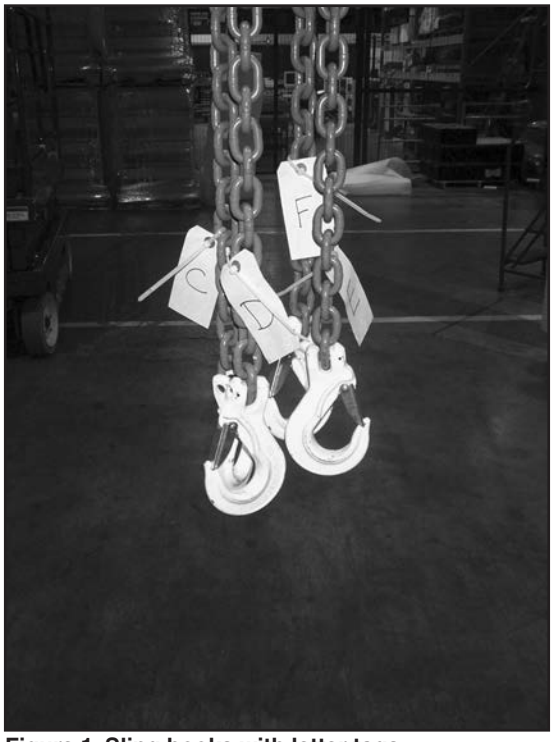


Figure 1. Sling hooks with letter tags.

Figure 2. Section ready to lift.

DIMENSIONS AND WEIGHTS

Section Dimensions and Weights

System			Dimensions L × D × H (in.)①	Number of Sections	Approximate System Weight (lbs.)			Total System Weight (lbs.)
KVAR	Voltage	Stages			Control Section	Capacitor Section 1	Capacitor Section 2	
500	480	3	87 × 37 × 121	1	6,000	—	—	6,000
	600	3	87 × 37 × 121	1	5,500	—	—	5,500
625	480	3	87 × 37 × 121	1	6,500	—	—	6,500
	600	3	87 × 37 × 121	1	6,000	—	—	6,000
750	480	3	87 × 37 × 121	1	7,500	—	—	7,500
	600	3	87 × 37 × 121	1	7,000	—	—	7,000
1000	480	3	87 × 37 × 121	1	8,500	—	—	8,500
	600	3	87 × 37 × 121	1	8,000	—	—	8,000
1250	480	3	174 × 37 × 121	2	7,000	2,500	—	9,500
		4	174 × 37 × 121	2	7,000	2,500	—	9,500
	600	3	87 × 37 × 121	1	9,000	—	—	9,000
		4	87 × 37 × 121	1	9,000	—	—	9,000
1500	480	3	174 × 37 × 121	2	7,500	3,000	—	10,500
		4	174 × 37 × 121	2	7,500	3,000	—	10,500
	600	3	87 × 37 × 121	1	9,500	—	—	9,500
		4	174 × 37 × 121	2	7,000	2,500	—	9,500
2000	480	3	174 × 37 × 121	2	8,000	3,500	—	11,500
		4	174 × 37 × 121	2	8,000	3,500	—	11,500
	600	3	174 × 37 × 121	2	7,500	3,000	—	10,500
		4	174 × 37 × 121	2	7,500	3,000	—	10,500
2500	480	3	261 × 37 × 121	3	8,500	4,000	3,500	16,000
		4	261 × 37 × 121	3	8,500	4,000	3,500	16,000
	600	3	174 × 37 × 121	2	8,000	3,500	—	11,500
		4	174 × 37 × 121	2	8,000	3,500	—	11,500
3000	480	3	261 × 37 × 121	3	9,000	4,000	3,500	16,500
		4	261 × 37 × 121	3	9,000	4,000	3,500	16,500
	600	3	174 × 37 × 121	2	8,500	3,500	—	12,000
		4	174 × 37 × 121	2	8,500	3,500	—	12,000
4000	480	3	261 × 37 × 121	3	9,500	4,000	3,500	17,000
		4	261 × 37 × 121	3	9,500	4,000	3,500	17,000
	600	3	261 × 37 × 121	3	9,000	4,000	3,000	16,000
		4	261 × 37 × 121	3	9,000	4,000	3,000	16,000
5000	480	3	261 × 37 × 121	3	10,000	4,000	4,000	18,000
		4	261 × 37 × 121	3	10,000	4,000	4,000	18,000
	600	3	261 × 37 × 121	3	9,500	4,000	3,500	17,000
		4	261 × 37 × 121	3	9,500	4,000	3,500	17,000
6000	600	3	261 × 37 × 121	3	10,000	4,000	4,000	18,000
		4	261 × 37 × 121	3	10,000	4,000	4,000	18,000

① Height dimension includes outdoor fan. Height dimension with indoor fan is 108 inches. Height dimension with fan housing removed is 102 inches.

Storage

If possible, the PureWave AVC should be immediately installed in its permanent location. In outdoor applications, the space heaters should be energized at once, even if the device itself is not to be energized until later. If the PureWave AVC cannot be installed immediately, storage in a clean, dry room is recommended, especially for a unit designed for indoor installation. The PureWave AVC should be protected against condensation, harmful gases, cement dust, and physical damage. If necessary, the device can be temporarily stored outdoors prior to being installed and put into service. Shelter it with a tent-like covering which will allow adequate ventilation but prevent entry of rain, snow, and contaminants through openings in the device. If the PureWave AVC is to be stored outdoors for more than two weeks, connect and energize the space heaters to minimize condensation.

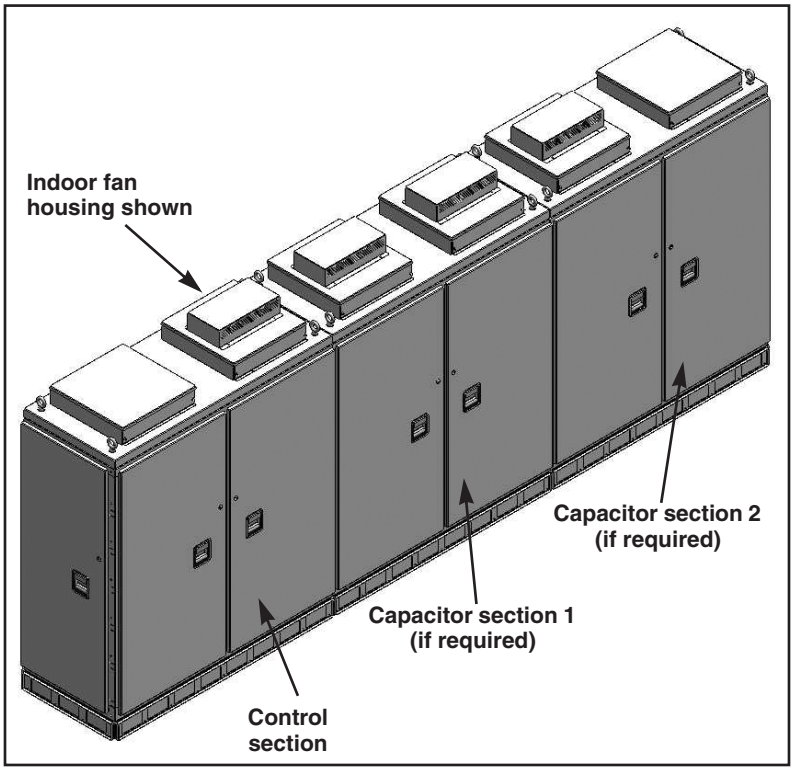


Figure 3. Section placement.

Placement

1. Note the positions of the control section and each of the capacitor sections. See Figure 3. Determine the section having working clearances most affected by adjacent walls or structures . . . this section should be placed first.
2. Unbolt each section from its skid and lift it into position on the pad or floor, observing the precautions discussed under “Handling” on page 7.
3. Fan housings may have been removed for shipping. Reinstall the fan housings using the hardware provided. See Figure 4.

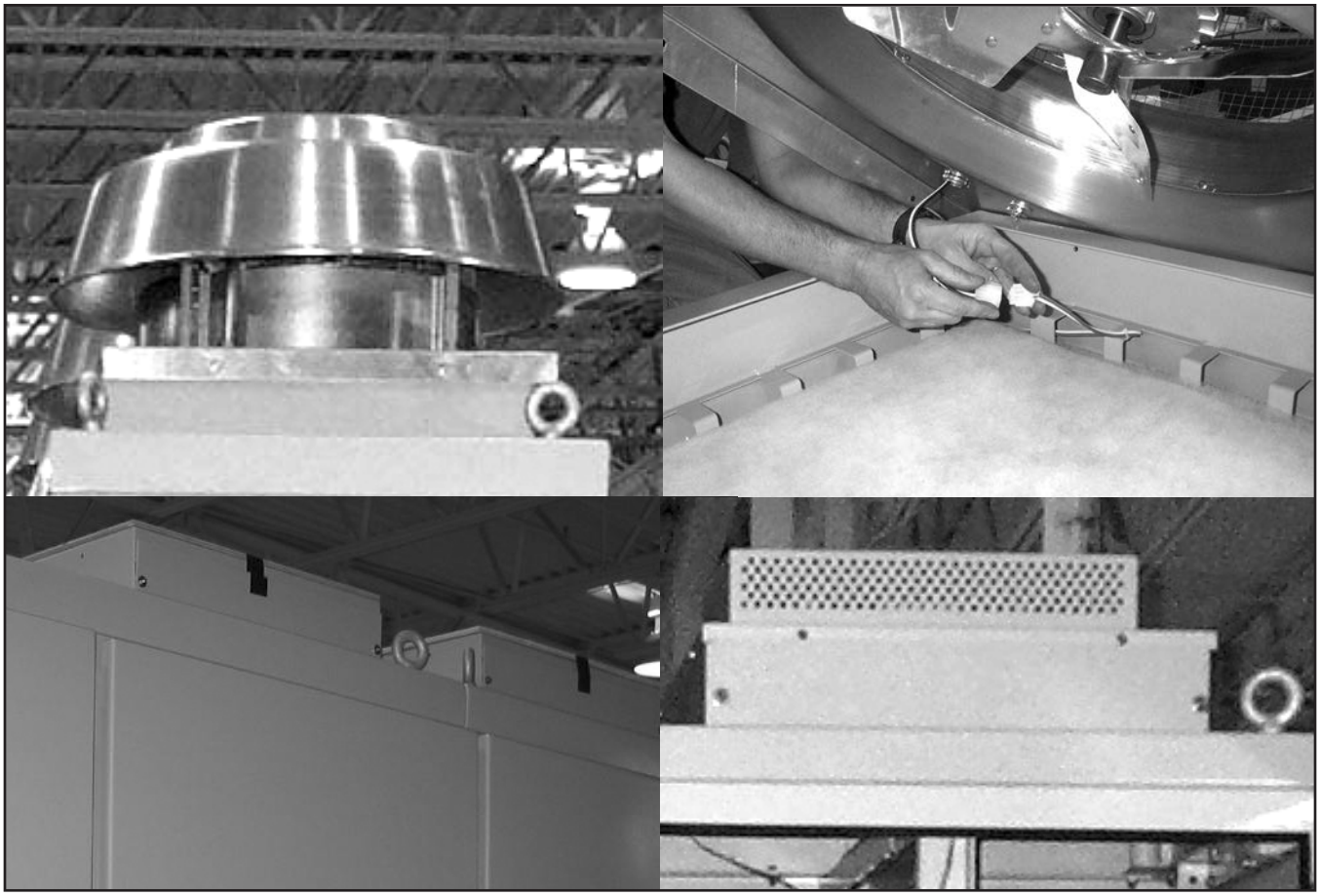


Figure 4. Outdoor fan housing (upper left). Fan power connection (upper right). Fans removed for shipping (lower left). Indoor fan housing (lower right).

Assembly

If the sections have shipped unassembled, assemble them as follows:

1. Remove the wood panels attached to the ends of the sections. Connect adjacent sections using supplied hardware (eighteen ⅜-16 × 1½ hex-head bolts, square flat washers, lock washers, and nuts). See Figure 5. Tighten each bolt to 240 inch-pounds. For outdoor installations, use supplied gasket material between sections.
2. Install the rear bus splices. See Figure 5 and Figure 6. Thoroughly abraid the Aluminum buses and splices to remove any dirt or oxidation prior to making the connections. Coat the contact surfaces to ½ inch beyond the joint with a uniform layer of Penetrox® A compound. Attach the splice plates using four ½″ hex-head bolts, Belleville washers, and nuts supplied. Tighten each bolt to 480 inch-pounds.

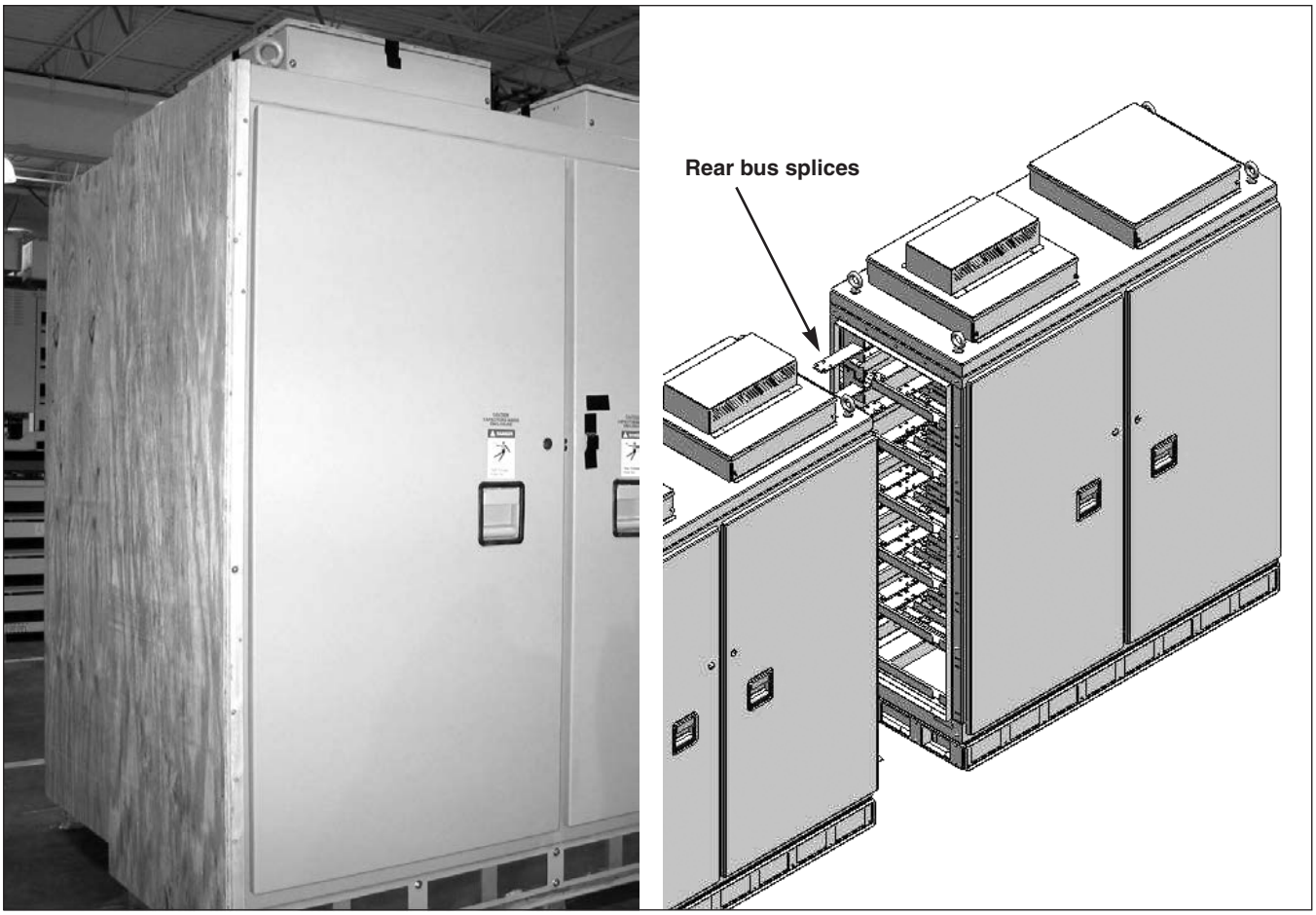


Figure 5. Individual section with wood panel at end. Sections are joined as shown.

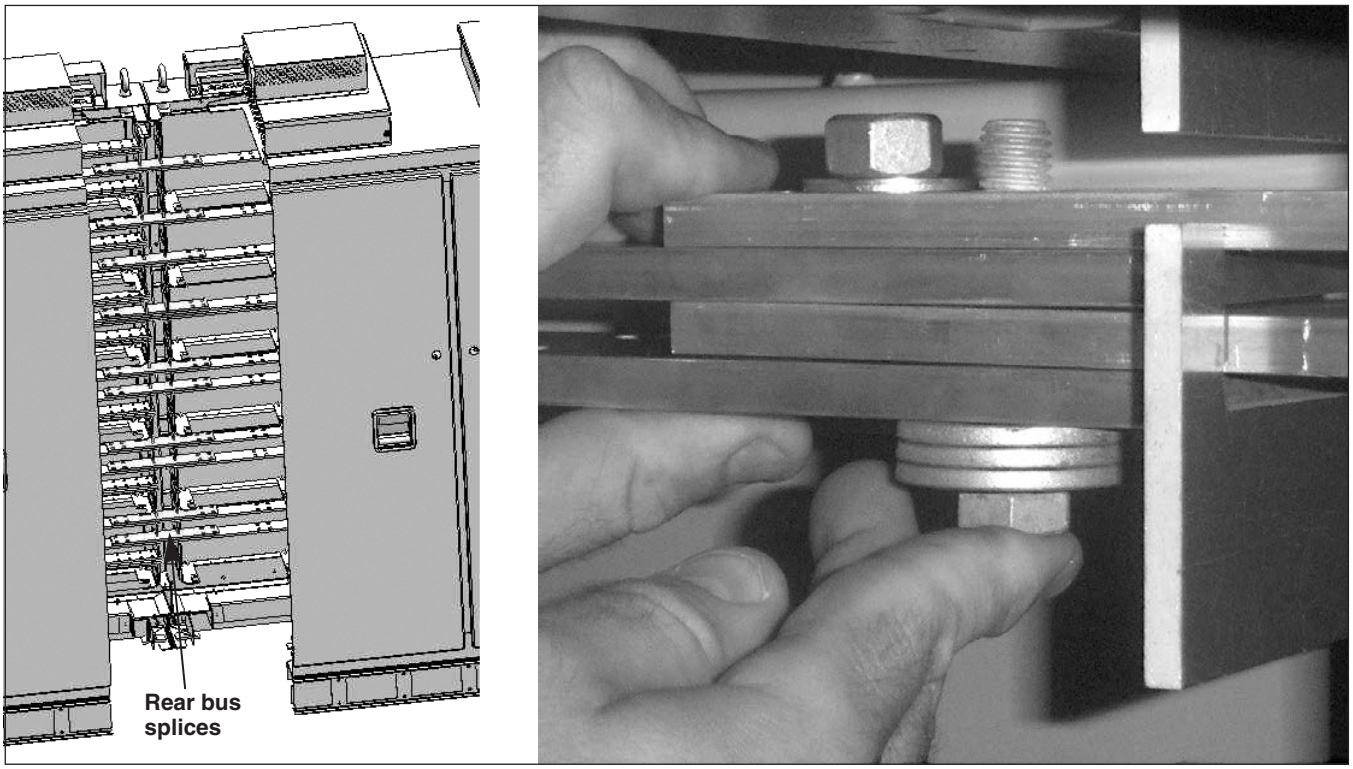


Figure 6. Cutaway view between sections showing rear bus splices (left) and close-up of splice hardware (right). In some cases, multiple washers may be required to maintain a minimum ¾-inch air gap between hardware and adjacent buses or structure; see the drawings furnished.

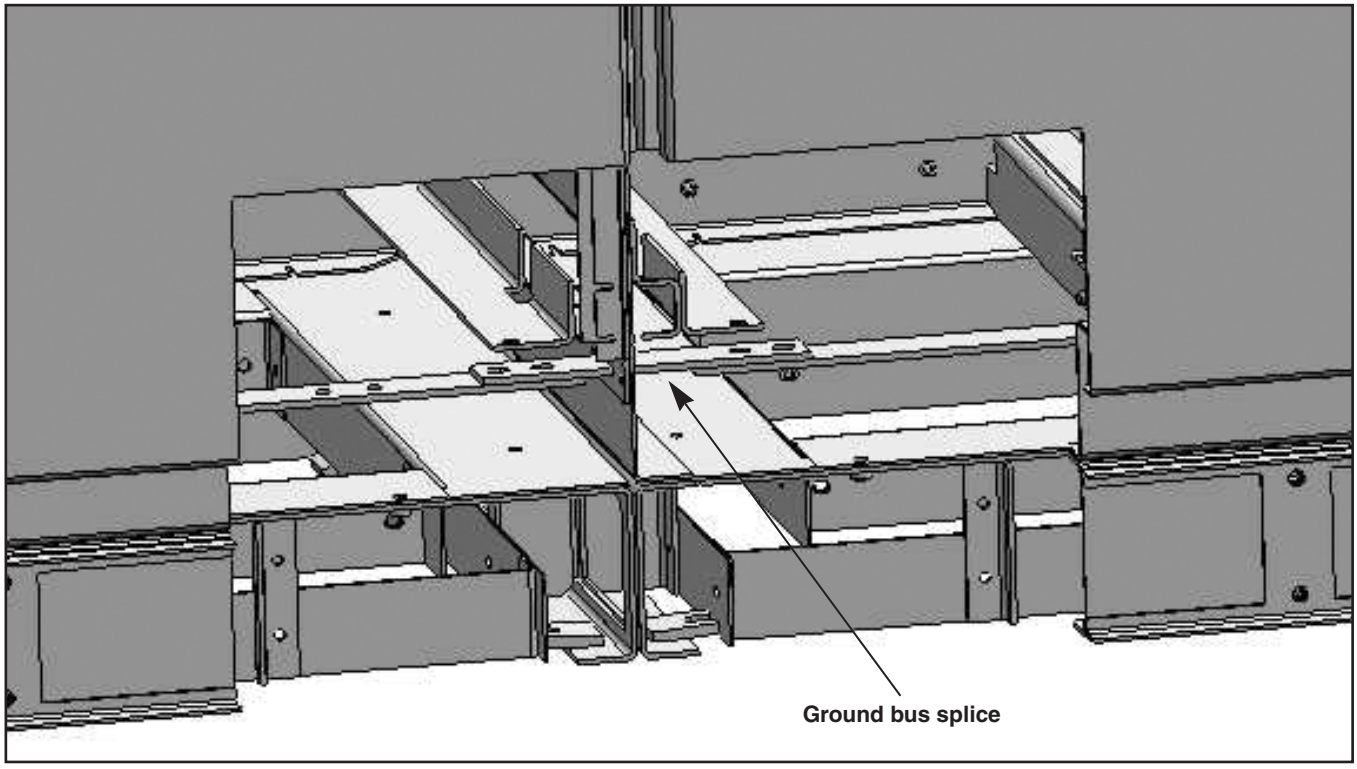


Figure 7. Ground bus splice cutaway view. In some cases, the lower tray(s) must be temporarily removed to access the ground bus splice and anchor brackets.

3. Install anchor brackets to secure the PureWave AVC to the pad or floor. At a minimum, there should be two brackets on the left side and two on the right side of the AVC, located approximately 6 inches from each corner. See Figure 8. Depending on the configuration, the bottom flange may point inward or outward. An inward flange will require anchor brackets inside the unit – capacitor trays may have to be temporarily removed to access the inside corners to mount the anchor bolts. See Figure 7. Anchor brackets on outward-facing flanges should be placed to minimize the chance to tripping on the anchor.

Access to Interior

To open a door: Remove the padlock and pull the door handle outwards. See Figure 9. If key interlocks have been provided, insert the key. When the door is opened slightly past 90 degrees, the door holder at the bottom will engage and prevent the door from closing accidentally.

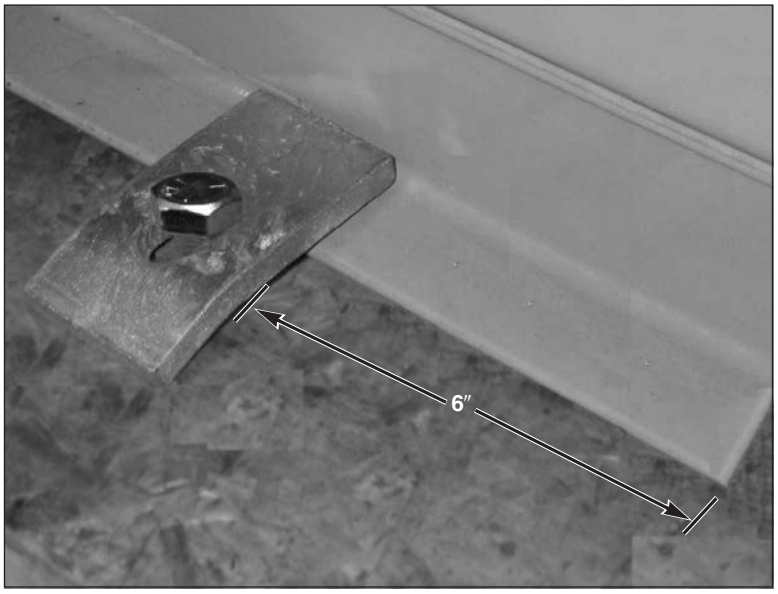


Figure 8. Anchor bracket installation.

Figure 9. Access to interior.

To close a door: Depress the door holder with your foot while pushing the door in the closing direction. See Figure 10. Remove your foot and close the door completely. Push the door handle up and install the padlock.

Grounding

1. Connect the cable ground wires to the grounding system as appropriate.
2. Connect the ground pad of the PureWave AVC to the facility system ground in accordance with the user's standard grounding practice and local codes. See Figure 11. Use the equivalent of 4/0 copper (or cable sized in accordance with the user's standard practice) in either a single or multiple connection to attain the momentary rating of the unit. For a multiple connection, cables smaller than 1/0 copper or equivalent should not be used.

Figure 10. Door holder release with foot.

Figure 11. Attach grounding pad to facility system ground.

Conduit Requirements

The size and quantity of conduits required is dependent upon the options ordered with the PureWave AVC. The PureWave AVC may be designed for connection using underground conduit or overhead raceway.

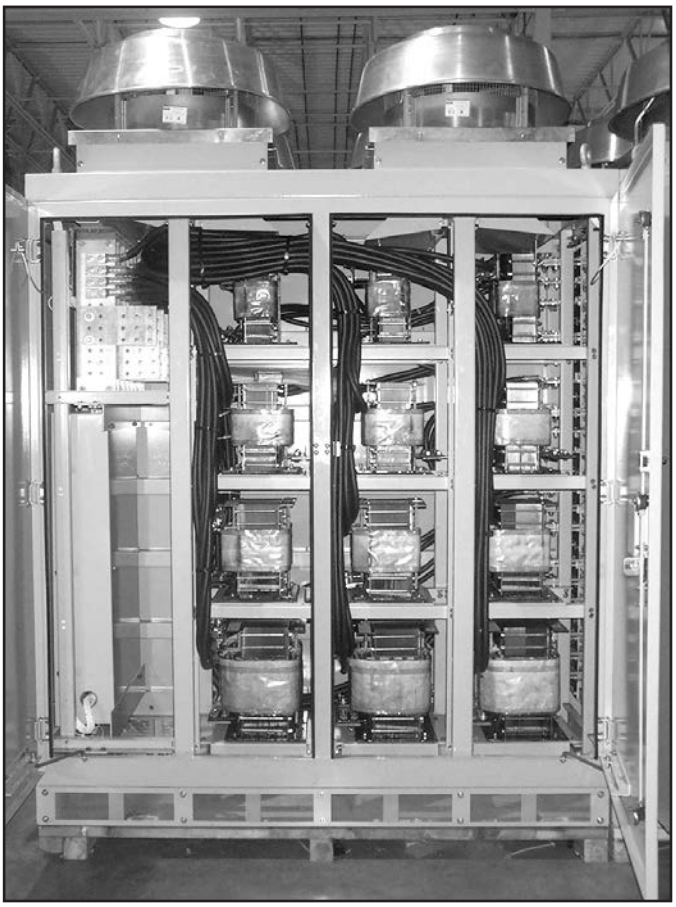


Figure 12. Control section shown with output connections for underground conduit (left). Close-up of cable entry area behind control panel (right).

Output Connections

1. Open the door of the control section to access the output connections. See Figures 12 and 13 and the drawings furnished.

   Note: The bus construction in the PureWave AVC is typically aluminum. Terminal pads on components may be aluminum, copper, or copper alloy. Hence, bus and terminal connections are typically aluminum-to-aluminum or aluminum-to-copper. Such connections employ Belleville washers. Do not tighten factory-made connections employing Belleville washers unless they are visibly loose; they have been correctly torqued to 50 foot-pounds at the factory. Other connections employ flat washers; if they have loosened, they should be torqued to 35 foot-pounds. Check bus connections and, where necessary, correctly tighten the connecting hardware.

   a. For aluminum terminal pads to aluminum connectors: Use aluminum or galvanized-steel hardware with two Belleville washers (not furnished). Torque each aluminum bolt to the manufacturer's specifications. Torque each steel bolt to 50 foot-pounds or, in the

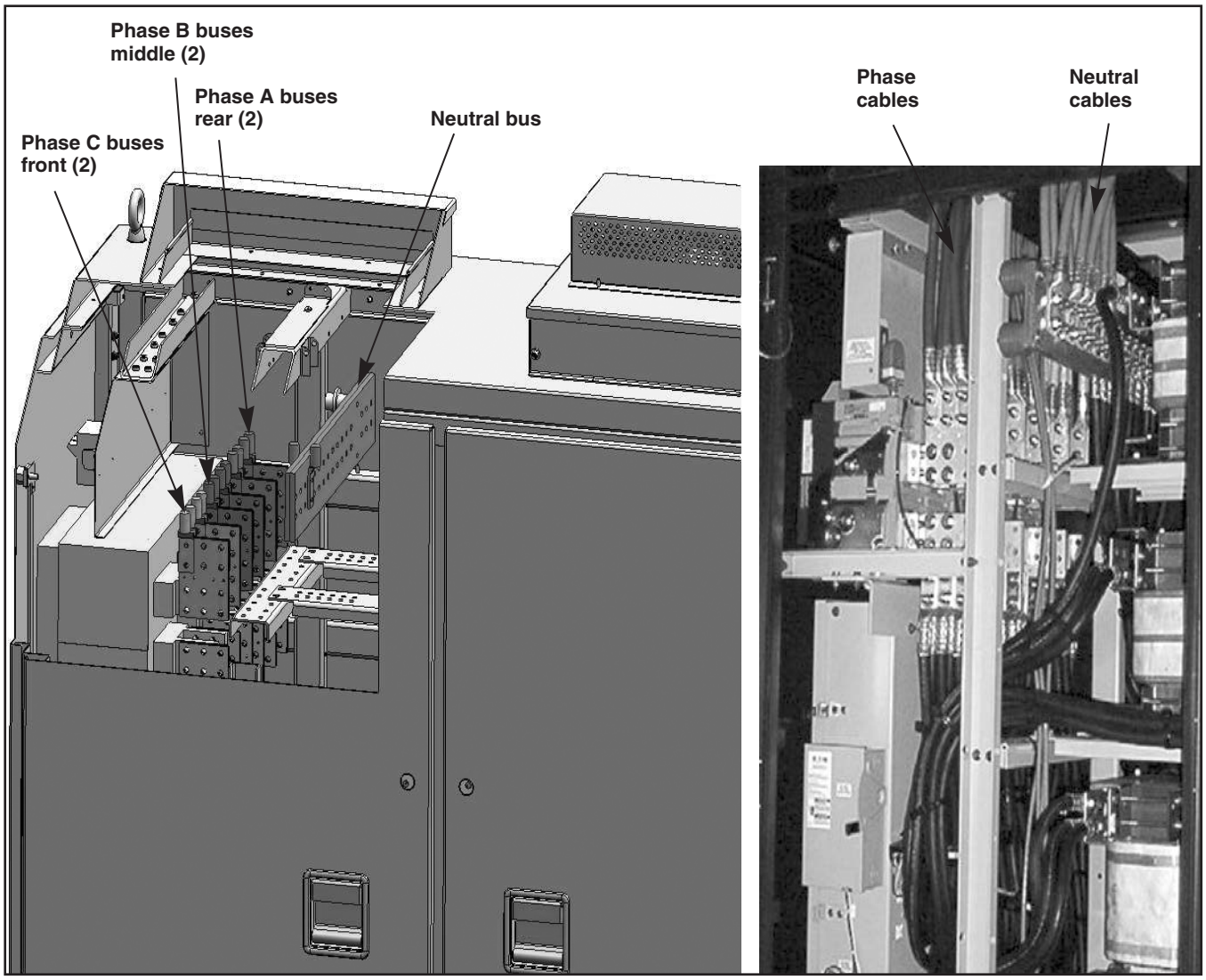


Figure 13. Control section cutaway shown with output connections for overhead raceway, with internal circuit breaker option (left). Close-up of cable entry area after output connections have been made (right).

absence of a torque wrench, tighten each bolt until the Belleville washers are flat, then back off one-half turn. Do not use lock washers with Belleville washers.

b. For aluminum terminal pads to tinned-copper or tinned-bronze connectors: Use galvanized-steel hardware, with one Belleville washer (not furnished) against the aluminum terminal pad and one galvanized-steel flat washer against the tinned connector. Torque each bolt to 50 foot-pounds or, in the absence of a torque wrench, tighten each bolt until the Belleville washer is flat, then back off one-half turn. Do not use lock washers with Belleville washers.

c. For copper terminal pads to tinned-copper or tinned-bronze connectors use Everdur or stainless-steel hardware, with one galvanized-steel or brass flat washer against each terminal pad and one split lock washer under the nut. Torque each bolt to 35 foot-pounds or, in the absence of a torque wrench, tighten each bolt until the split lock washer is flat.

d. For copper terminal pads to aluminum connectors, use galvanized-steel hardware with one Belleville washer against the connector and one galvanized-steel or brass flat washer against the terminal pad. Torque each bolt to 50 foot-pounds or, in the absence of a torque wrench, tighten each bolt until the Belleville washer is flat, then back off one-half turn. Do not use lock washers with Belleville washers.

2. Complete the phase connections to the PureWave AVC terminals. Thoroughly wire-brush aluminum contact surfaces to remove dirt or foreign materials as well as natural surface oxides. Immediately coat the surfaces to ½ inch beyond the joint with a uniform layer of Penetrox A compound.

3. For outdoor installations, seal all external conduits with RTV, and seal all conduit openings inside the enclosure with expansive foam to prevent water from entering the enclosure through the conduit.

Completing the Installation

1. Depending on the configuration, provide 110-Vac or 208-Vac control voltage inside the control section to power the fans and controls. See Figure 14.
2. Close and lock all doors on the PureWave AVC.
3. Wipe down the exterior of the enclosure with a clean, damp cloth. Refinish any scratches or abrasions with S&C red-oxide primer and touch-up finish, which are available in aerosol spray cans. See Figure 15. Order Catalog Number 9999-061 red-oxide primer and Catalog Number 9999-080 light gray finish. No other primer or finish is approved. The area to be touched up should be cleaned to remove all oil and grease. Sand the area, removing any traces of rust that may be present. make sure that all edges are feathured before applying primer.

Figure 14. 110-Vac, 30-A safety switch configuration (left), 208-Vac panel board for larger, outdoor applications (right).

Figure 15. S&C red-oxide primer and touch-up finish.

⚠ CAUTION

Before walking away. . .

1. Check the interior of the unit for foreign materials, tools, etc., which may have been mislaid on bus work or supporting members.
2. Make certain that controls are in the desired positions.
3. Make certain that fuses are installed and breakers are in the proper position.
4. Close and securely latch all doors.
5. Make certain that all temporary grounds have been removed.
6. Padlock all door handles.

The PureWave AVC provides transient-free cycle-per-cycle reactive power compensation. The concept for this device was developed by the University of Washington in conjunction with the Bonneville Power Administration and Southern California Edison.

The PureWave Adaptive VAR Compensator is a solid-state switched capacitor bank which is connected in parallel with the variable reactive load. Depending on its kVAR rating, the PureWave AVC provides the total reactive power required by a variable reactive load within one cycle of the power frequency. The dynamic response of the PureWave AVC offers quality enhanced electric power to the user by providing adaptive reactive power control, which leads to the following benefits in commercial, industrial, or utility installations:

- Voltage stabilization.
- Electric loss reduction.
- Improved usage of installed capacity.
- Reduction of peak demand charges.
- Reduction of energy consumption.
- Reduction of power factor penalty.

The PureWave AVC consists of power elements including capacitor stages and power-electronic switches, a microprocessor-based controller, and auxiliary equipment such as potential and current transformers.

Capacitor Stages

The per-phase reactive power supplied by the PureWave AVC is divided into binary increments. If Q1 is the reactive power (in kVARs) generated by the first capacitor stage, then—for a four-stage PureWave AVC—the second stage has a reactive power of $2 \times$ Q1 (twice the kVARs of the first stage). The third stage has a value of $4 \times$ Q1 (four times the kVARs of the first stage). And the fourth stage has a value of $8 \times$ Q1 (eight times the kVARs of the first stage). The total reactive power of the PureWave AVC is calculated as $3 \times Q1 \times (2^0 + 2^1 + 2^2 + 2^3)$. The number of stages and the value of Q1 are determined by the requirements of the application.

Each capacitor stage has a discharge resistor that dissipates the stored energy, reducing the voltage across the capacitor terminals to 50 volts within 5 minutes after disconnection.

Power-Electronic Switches

Each capacitor stage is controlled by a set of power-electronic switches composed of an SCR and a diode connected in anti-parallel. The diode performs two basic functions: It charges the capacitors in each stage to the negative peak value of the supply voltage and it provides a path for the flow of the negative half cycle of capacitor current.

When the supply voltage crosses zero becoming negative, the diodes conduct, charging the capacitors to the negative peak value of the supply voltage. At this instant, the PureWave AVC current reverses direction and the diodes stop conducting. All capacitors are thus precharged and remain in that condition until a control signal is sent to the SCRs to set them in the conducting mode. While the thyristors are not conducting, the discharge resistors tend to dissipate the energy stored in the capacitors. However, during this short time (one cycle), the change in the stored energy and the voltage across the capacitors are negligible.

Microprocessor Controller

The microprocessor controller continuously monitors the phase voltages and the load current. Based on the magnitude of the imaginary component of the load current, the controller calculates the appropriate triggering sequence of the SCRs needed to compensate for the reactive power requirement at that moment. Maximum compensation capability is determined by the total rated kVAR of the PureWave AVC. System voltage and current waveforms are used as references by the controller. They are filtered of all harmonics and transient distortions so that compensation is based on the 60-Hz or fundamental components. The required reactive power is supplied by the PureWave AVC and injected into the system during the following cycle, giving a maximum response time of one cycle, or 16.6 milliseconds for a 60-Hz power system. Complete compensation is achieved when the line current is in phase with its respective phase voltage.

Start Up

Upon energizing the PureWave AVC in RUN Mode, or after a power outage, the microprocessor controller starts automatically; firing of the thyristors is prevented. A self-calibration routine is executed. Once the proper firing sequence of the thyristors has been determined, the PureWave AVC goes into automatic steady-state operation. Start-up time is approximately 30 seconds.

To start up the PureWave AVC:

1. Place the **STANDBY/RUN** switch on the control section in the **RUN** position. See Figure 16.
2. If a circuit breaker has been furnished in the PureWave AVC, press the **CLOSE** push button on the control section. (In some configurations, **OPEN** and **CLOSE** push buttons may be mounted on the control section door. If a circuit breaker has not been furnished in the PureWave AVC, close the external circuit breaker or disconnect switch.

⚠ DANGER

This equipment contains high voltage. Do not attempt to access the interior of the control section or capacitor section(s) when the PureWave AVC is energized. Failure to observe this precaution may result in serious injury or death.

Off-Line Operation

The PureWave AVC can be operated in standby mode to permit control system configuration. In this operating mode, triggering signals to the SCRs are disabled.

To operate the PureWave AVC off-line: Place the **STANDBY/RUN** switch on the control section in the **STANDBY** position. See Figure 16.

To again operate the PureWave AVC on-line: Place the **STANDBY/RUN** switch on the control section in the **RUN** position.

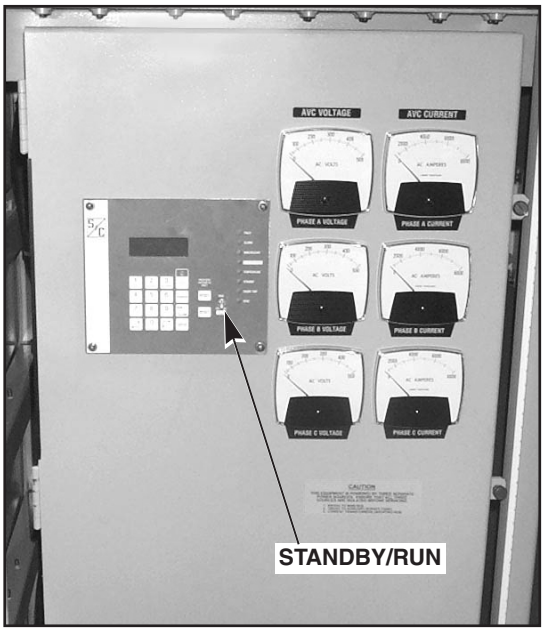


Figure 16. Control panel.

Shut Down

To shut down the PureWave AVC:

1. Place the **STANDBY/RUN** switch on the control section in the **STANDBY** position. See Figure 16.
2. If a circuit breaker has been furnished in the PureWave AVC, press the **OPEN** push button on the control section. The circuit breaker can also be tripped remotely by means of the communication package; refer to the user's manual for the PureWave AVC communication package. If a circuit breaker has not been furnished in the PureWave AVC, open the external circuit breaker or disconnect switch.

The capacitor trays are provided with a discharge resistor as a path for dissipating stored energy. Discharge occurs such that the stored voltage is reduced to 50 volts, 1 minute after de-energization.

⚠ DANGER

This equipment contains high voltage. Do not attempt to access the interior of the control section or capacitor section(s) when the PureWave AVC is energized. After tripping the circuit breaker or opening the disconnect switch, wait at least 5 minutes before entering a capacitor section, to allows the capacitors to discharge. Failure to observe this precaution may result in serious injury or death.

Capacitor Fuses

Each capacitor stage consists of groups of capacitor cells mounted on modular trays. Each capacitor stage is protected by a semiconductor-grade fuse.

Inrush-Limiting Reactors

Some PureWave AVCs are fitted with detuning reactors. These reactors prevent resonance-related problems and limit the rate of rise of SCR current to limits specified by the SCR supplier.

Cooling of SCR/Diode Valves

Each SCR/diode heat sink includes a thermostatically controlled cooling fan. The cooling fan is turned on when the temperature at the surface of the heat sink exceeds 60° C. The fan turns off when the heat sink temperature cools to 45° C.

Heat-Sink Temperature Sensor

A temperature transducer, mounted on each SCR/diode heat sink, disables the triggering signal for that capacitor stage if the temperature reading on the surface of the heat sink exceeds 85° C, which is indicative of fan misoperation. Normal operation will resume when the heat sink temperature cools.

Surge Arresters

The PureWave AVC is provided with high-energy MOV surge arresters that offer protection against transient overvoltages in the power system. The arresters are placed at the cable entrance.

Frequency Scan

Synchronization of the SCR triggering times, set by the control program, is based on the zero crossing of the phase-to-neutral voltages. To avoid SCR misfires due to voltage waveform distortion, the microprocessor timing block calculates the time between two consecutive zero crossings. If the duration does not correspond to the 60-Hz power frequency, SCR firing signals are disabled for one cycle, or until the voltage waveform returns to normal.

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