PHOTOVOLTAIC POWER CONTROL

(PPC)

Photovoltaic Battery Charge Controller
Installation And Operation Manual

SPECIALTY CONCEPTS, INC.
8954 Mason Ave.
Chatsworth, CA 91311 USA

MODELS: PPC-12, PPC-24, PPC-36, PPC-48

GENERAL DESCRIPTION

The Photovoltaic Power Control (PPC) is a versatile, industrial quality charge controller for the efficient use of photovoltaic energy and the protection of expensive batteries. It is available for 12, 24, 36, and 48 volt negative ground systems with models for 30 amps of charge current (optional 50 amps available) .

The PPC consists of a series-relay battery charge controller in a wall mount enclosure with low- voltage load disconnect, a load circuit breaker, array fuse, metering and system status lights. The lights indicate "CHARGE MODE" and "LOAD DISCONNECT" conditions and the meters monitor battery voltage and charging current, providing system status and information.

FEATURES

CHARGE REGULATION
- 30 amp charge current, 12, 24, 36 or 48 volt
- 50 amp charge current available (P option) for 12 and 24 volt units
- Two-step, series charging, 12,24 v
- Single step, series charging, 36,48 v
- Adjustable charging set-points
- Temperature compensation

LOW-VOLTAGE LOAD DISCONNECT (LVD)
- 30 amp LVD, 12 volt
- 20 amp LVD, 24 volt
- 15 amp LVD, 36 and 48 volt
- Adjustable disconnect set-points
- Manual override switch

DESIGN FEATURES
- Maximum array usage
- Over-current protection: Array fuse (30 amp units)
- Over-current protection: Load circuit breaker
- Reverse polarity protection
- Reverse leakage protection
- Lightning protection
- Input noise suppression
- Remote battery voltage sense

MONITORING / MOUNTING
- Analog volt / amp meter
- Charging light
- Load disconnected light
- Indoor wall mount enclosure
- Outdoor enclosure (optional)

S P E C I F I C A T I O N S

PARAMETERS	UNITS	NOMINAL VOLTAGES			
		12 v	24 v	36 v	48 v
Charge Current, Continuous (1)	(Amps)	30	30	30	30
Charge Current, Max (60 seconds) (2)	(Amps)	39	39	39	39
Load Current, Continuous (3)	(Amps)	30	20	15	15
Load Current, Max (60 seconds) (4)	(Amps)	39	26	20	20
Array Voltage, Max Voc	(Volts)	22	44	66	88
Operating Voltage @ Battery, Minimum	(Volts)	8.5	17.0	25.5	34.0
Quiescent Current (5)	(Milliamps)	10	10	10	10
Current Consumption, Charging (6)	(Milliamps)	160	160	80	80
Current Consumption, Load Disconnected (7)	(Milliamps)	140	100	70	70
Voltage Drop, Typ. (Array to Battery)	(Volts @ Max rating)	.15	.15	.15	.15
Voltage Drop, Typ. (Battery to Load)	(Volts @ Max rating)	.40	.40	.40	.40
Full Charge Termination (8)	(Volts)	14.8 ± .2	29.6 ± .4	44.4 ± .6	59.2 ± .8
Full Charge Resumption	(Volts)	12.8 ± .2	25.6 ± .4	38.4 ± .6	51.2 + .8
Load Disconnect (9)	(Volts)	11.5 ± . 2	23.0 ± .4	34.5 ± .6	46.0 ± .8
Load Disconnect Adjustment Range	(Volts)	11.0 to 12.0	22.0 to 24.0	33.0 to 36.0	44.0 to 48.0
Load Reconnect	(Volts)	13.0 ± .3	26.0 ± .6	39.0 ± .9	52.0 ± 1.2
Float Voltage	(Volts)	14.1 ± .2	28.2 ± .4	NA	NA
Float Current, Max	(Amps)	3	1	NA	NA
Meter Accuracy, Voltage		5 %	5 %	5 %	5%
Meter Accuracy, Current		5 %	5 %	5 %	5%
Temp. Compensation coef.(from 25°C)	(Volts/°C)	-.03	-.06	-.09	-.12
Operating Temp. Range	(°C)	-20 to 50	-20 to 50	-20 to 50	-20 to 50
Storage Temp. Range	(°C)	-55 to 85	-55 to 85	-55 to 85	-55 to 85

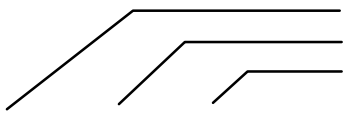
Notes:
(1) 50 amp option available (avail. on 12, 24v units)
(2) With 50 amp option, value is 65 amps
(3) Non-inductive.
(4) Carry only, Non-switching
(5) Both relays unenergized, red L.E.D.s off, typical value.
(6) Charge relay energized, red L.E.D. on, typical value.
(7) LVD relay energized, red L.E.D. on, typical value.
(8) Set-point adjustable. Refer to table.

FULL CHARGE TERMINATION SET-POINTS

Control Voltage	SWITCH POSITIONS A	B	C	D
12	15.3	14.8	14.3	13.8
24	30.6	29.6	28.6	27.6
36	45.9	44.4	42.9	41.4
48	61.2	59.2	57.2	55.2

P A R T N U M B E R I N G K E Y

EXAMPLE:



Model
Nominal Voltage
Options

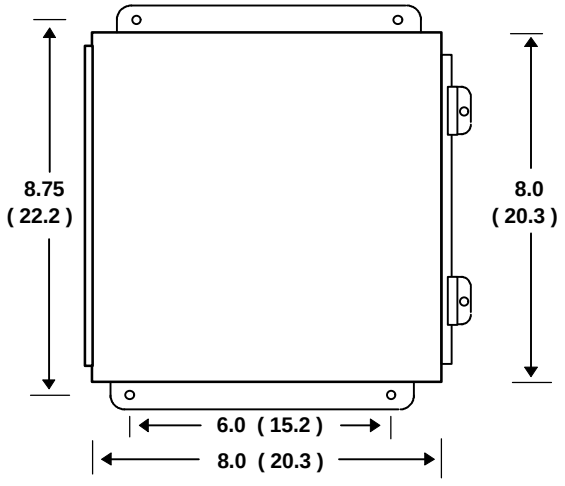
PPC - 12 - P

MODEL	NOMINAL VOLTAGE	OPTIONS
PPC	12	M - Outdoor enclosure -
	24	NEMA 4X
	36	P - 50 Amp charge current
	48	(12 or 24 volt units)

D I M E N S I O N S

In Inches (cm)

STANDARD ENCLOSURE (NEMA 13)



Depth: 4.5 Inch (11.4 cm)
Shipping weight: 10 lbs. (4.5 Kgs.)

Specifications and product availability subject to change without notice.

R E L A T E D S Y S T E M E Q U I P M E N T

The PPC is an integral part of a solar electric power system that includes a PV solar array, a battery and a load. These items should be installed in accordance with the National Electrical Code, and with the instructions provided by the equipment supplier.

SOLAR ARRAY PANELS: The PPC is compatible with all makes and models of PV panels, provided the open circuit voltage and the maximum power current of the array does not exceed the maximum open circuit voltage (Array Voltage, Max Voc) and the maximum charge current (Charge Current, Max) specifications for the PPC being used.

HIGHER CHARGING CURRENTS : For arrays exceeding the maximum power current of the PPC, the array can be divided into smaller parallel sub-arrays. A PPC can be wired in parallel to each sub-array, provided the sub-arrays do not exceed the rating of the individual PPC.

BATTERIES: The standard PPC is designed to be used with the most common lead-acid batteries. These are wet cell batteries using pure lead, lead antinomy and/or lead calcium grids. For sealed, maintenance free batteries, or vented pocket plate nickel-cadmium batteries, the charging set-points should be adjusted to maximize performance and battery life. For sealed, maintenance free batteries or nickel cadmium batteries, consult the battery manufacturer for recommended set-points and refer to Table 2 for appropriate settings.

LOADS: The load is considered the item or equipment that the PV system is powering. System loads such as lights, radios, DC/AC inverters, etc. must be rated for the proper DC input voltage. DC loads not exceeding the rated PPC load current (see specification section) can be connected to the load terminals of the PPC and they will automatically be disconnected in the event of a low voltage condition. Higher current, or inductive loads such as pumps, motors or inverters should be connected directly to the battery, using properly rated over current protection devices (fuses or circuit breakers).

OTHER CHARGING SOURCES: Do not use the PPC to regulate a power source other than a photovoltaic array, such as a hydro or wind generator/alternator or an AC battery charger. This could result in damage to the PPC and/or the generating equipment. Connect other charging sources with their own regulation devices directly to the battery, using properly rated over current protection devices.

The PPC and array can remain connected to a battery being charged by other sources, (alternator, battery charger, etc.) without damage to the control or solar array.

I N S T A L L A T I O N

WARNINGS / CAUTIONS

WARNING : Electricity, even low voltage electricity, can be dangerous. Installation should be performed by a licensed electrical contractor or other qualified personnel only. It is recommended that the requirements of the U.S. National Electrical Code be followed.

WARNING : Follow all battery safety precautions of the battery manufacturer and the National Electrical Code. Proper ventilation must be provided for vented batteries. Most vented batteries produce hydrogen gas when charging, which is extremely explosive. DO NOT expose the battery to open flame, matches, cigarettes or sparks.

WARNING: Install properly DC rated, high interrupt, current limiting over-current protection and disconnect equipment between the PPC and the battery. Suitable fused disconnect switches are low cost and provide protection from fire and damage due to over current. Refer to the current National Electrical Code or your local alternative energy vendor for recommendations.

CAUTION : DO NOT subject the controller to voltages greater than the "Array Voltage, Max Voc" as stated in the Specifications section. This is the open circuit voltage (Voc) of the array, or the sum of the open circuit voltages of all modules connected in series.

CAUTION : DO NOT exceed the maximum current rating ("Charge Current, Max") of 30 amps (or 50 amps with P-Option). This is the sum of the maximum power currents of all the modules in parallel.

CAUTION : On higher voltage units (36, 48 volt), exercise extreme care during installation. These voltages can be extremely dangerous in that they can create large arcs, which can burn or cause other injuries.

INSTALLATION INSTRUCTIONS:

1. LOCATION: - A suitable location must be found for mounting the PPC. The unit should be mounted on a vertical surface and be as close as possible to the batteries to avoid errors in battery voltage reading. The temperature sensor wire is 10 feet long and should reach the battery bank if possible.

2. PROTECTION REQUIREMENTS: - The unit should not be placed in direct sunlight or close to any heat generating source to avoid extreme temperature increases. It must receive adequate protection from rain, dust and insects. The standard PPC is supplied in an indoor NEMA 13 enclosure, or an optional outdoor enclosure is available.

3. MOUNT THE PPC ENCLOSURE: - Remove the inner panel of the PPC by unscrewing the four acorn nuts in the four corners. Determine the size and location of holes needed in the enclosure for conduit hubs or strain relief feed-throughs for the wiring. Proceed with making holes in the steel NEMA 13 enclosure or the plastic NEMA 4X enclosure. Then clean out any debris and replace the internal panel.

4. COMPLETE THE INSTALLATION OF THE PANELS, BATTERIES AND LOAD: - Follow the manufacturer's instructions for mounting and wiring the solar panel, batteries and the load.

5. SELECT WIRE:

WIRE TYPE: - It is recommended that stranded wire rather than solid wire be used whenever possible, because stranded wire does not fatigue and cause loose connections over time as easily as solid wire does.

WIRE SIZE: - The standard PPC terminal block accepts bare wire up to 10 AWG. (The 50 amp model accepts up to 6 AWG). Wire should be sized of sufficient gauge to safely handle the rated current of the system and to limit voltage drop. Consult wire sizing tables and local alternative energy system suppliers for information on wire sizing.

6. REMOVE POWER FROM BATTERY / PANELS: - Disconnect power from the batteries and panels prior to running the wires to the PPC to prevent accidental damage or bodily harm.

7. SET CIRCUIT BREAKER TO "OFF": - Make sure the load circuit breaker on the PPC is "OFF".

8. RUN SYSTEM WIRING: - After disconnecting the power sources, refer to wiring diagram (FIGURE 1) and run the system wiring to the location of the PPC. The wires should reach the location of the PPC with a little extra for strain relief loops.

9. NOTE WIRE POLARITY: - Insure that the polarity of the wires is correctly marked, using colored wires or tags. Incorrect polarity should not damage the PPC, but incorrect operation would result.

10. COMPLETE ARRAY AND BATTERY CONNECTIONS: - Connections to the PPC terminal block should be made with just the bare wire (not crimped spade or ring lugs unless the lugs are crimped AND soldered)

11. COMPLETE LOAD CONNECTIONS: - Refer to wiring diagram (FIGURE 1). DC loads not exceeding the rated PPC load current (see specification section “Load Current, Continuous”) can be connected to the load terminals of the PPC and they will automatically be disconnected in the event of a low-voltage condition. Higher current, or inductive loads such as pumps, motors or inverters should be connected directly to the battery, using properly rated over-current protection devices (fuses or circuit breakers).

12. BATTERY VOLTAGE SENSE CONNECTIONS: - The factory has installed two jumpers onto the terminal block. They connect the "BATTERY VOLTAGE SENSE" (positive and negative) terminal to their respective "BATTERY" terminals. These jumpers should remain in place if the PPC is located within 5-10 feet of the batteries and if large enough wire is used to minimize voltage drops to less than 2%.

If the PPC is at a greater distance from the batteries and/or if the voltage drop in the battery wires exceeds 2%, then the jumpers should be removed and replaced with another circuit running directly to the battery terminals. This is a low current, voltage sensing circuit that can be wired in 16 AWG wire. Proper over-current protection should be added on the positive side. This connection will allow the PPC to accurately measure battery voltage.

13. INSTALL FUSING AS NEEDED: - Add circuit protection where needed. A 30 amp fuse (or 50 amp with P-Option) should be installed on the Battery (+) run of the PPC. Fusing is also advised for the battery voltage sense connection, if included. The load is already protected by the built-in circuit breaker of the PPC.

14. ATTACH TEMPERATURE COMPENSATION CABLE: - *See Temperature Compensation section*

15. MAKE NEEDED ADJUSTMENTS TO SETTINGS: - *See Setting/Adjustments section*

16. RECONNECT BATTERY AND ARRAY POWER - Reconnect both power sources, then position the load circuit breaker on.

POWER CONNECT SEQUENCE

It is recommended that the power is supplied to the system using this sequence. Some of the circuits within the PPC must be reset to their "start state" and this is automatically accomplished if the power is supplied in this order. If the order is not followed, a period of up to 24 hours may have to elapse before the electronics are fully reset.

Step 1	**Battery (-) *(terminal # 7):***	To Battery (-)
Step 2	**Battery (+)*(# 2):***	To Battery (+)
Step 3	**Array (-)*(# 6):***	To Solar Panel Array (-)
Step 4	**Array (+)*(# 3):***	To Solar Panel Array (+)

Optional *(see "COMPLETE LOAD CONNECTION" above)*

Step 5	**Load Connect (-)*(# 5):***	To Load (-)
Step 6	**Load Connect (+)*(# 4):***	To Load (+)

If Needed *(see "BATTERY VOLTAGE SENSE CONNECTIONS" above)*

Step 7	**Battery Sense(-) *(# 8):***	To Battery (-). *(Remove #7-#8 jumper)*
Step 8	**Battery Sense(+)*(# 1):***	To Battery (+) *(Remove #1-#2 jumper)*

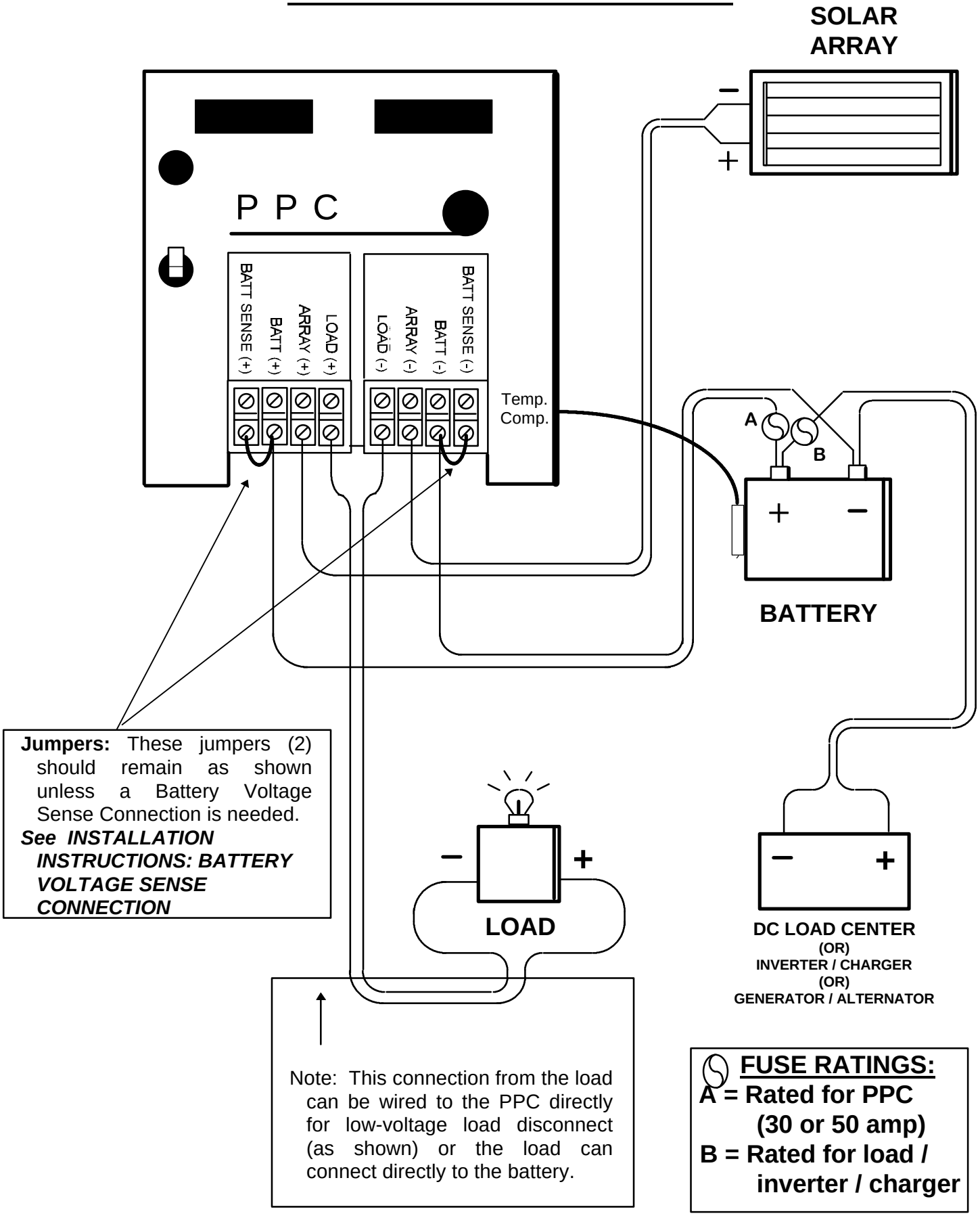
17. OPERATION: - Operation of the charge controller is now fully automatic. If the battery voltage is below the Full Charge Termination set-point (*see SPECIFICATIONS*) and power is available from the array and the Power Connect Sequence (above) was followed, the PPC should start up in the full-charge mode.

During float charging (12 or 24 volt units) it is normal for the unit to feel warm. This is due to power dissipation of the voltage regulated float circuit.

18. CHECK FOR VOLTAGE DROP (OPTIONAL): - Once the system is installed and operational, a check on the battery connection is recommended. A poor battery connection will result in a voltage loss that will cause the batteries to be under-charged and/or result in excessive heat generated at the location of poor connection (wire connection or terminal block). A voltage multi-meter is required and the PPC must be in Full Charge mode with maximum expected charge current.

First, note the voltage at the battery terminals. Select the positive and negative terminals that are used for the PPC connection. Then note the voltage at the PPC terminals labeled "BATT (+)" and "BATT (-)". The difference in voltage should be no more than ¼ volt (for a 12 volt system). If the voltage drop is more, suspect crimp connections that have not been soldered or loose terminals. If no location of voltage drop is found, consider using larger wires for your run or run a separate wire for the Battery Sense connection. See "BATTERY VOLTAGE SENSE CONNECTION" (above).

FIGURE 1
PHOTOVOLTAIC POWER CONTROL



Jumpers: These jumpers (2) should remain as shown unless a Battery Voltage Sense Connection is needed.
See INSTALLATION INSTRUCTIONS: BATTERY VOLTAGE SENSE CONNECTION

Note: This connection from the load can be wired to the PPC directly for low-voltage load disconnect (as shown) or the load can connect directly to the battery.

FUSE RATINGS:
A = Rated for PPC (30 or 50 amp)
B = Rated for load / inverter / charger

T E M P E R A T U R E C O M P E N S A T I O N

DESCRIPTION: - The PPC has a small sensor on a ten foot cable that is wired into the control to adjust the charging thresholds according to battery temperature. The rate of compensation is -5mv/°C per battery cell in series from 25° C.

WHEN NEEDED: - Temperature compensation is recommended for stand alone systems with sealed batteries, or for systems that have no regular charging source other than PV **AND** where prolonged temperature extremes will be experienced during periods of charging. Temperature extremes would be when the battery will be exposed to average temperatures below 50°F (10°C) or above 90°F (32°C).

CAUTION: SENSOR CABLE: If the sensor is damaged or the cable is cut, the control will no longer function.

INSTALLATION INSTRUCTIONS

Provision must be made to attach the sensor unit to the battery. This must be done properly to insure that accurate temperature readings are made. It is important that ambient temperature not influence the sensor. To minimize this, attach the sensor to the battery as follows:

1. **RUN SENSOR TO BATTERIES:** Run the sensor to the batteries, taking care to prevent damage to the actual sensor itself. When pulling the sensor through conduit, do not pull on the rubber-coated sensor, but instead on the gray cable just behind the sensor. Do not force the sensor. The sensor itself is made of glass, but it is encased in an aluminum tube, then coated with plastic. If the tube should pull off of the glass sensor, and if the sensor is not damaged, the tube can be slipped back over the sensor.

2. **ATTACH SENSOR:** Use the adhesive sided foam pad (included) to cover the sensor (the plastic coated unit at the end of the cable) and attach it to the side of the battery approximately half-way up the side of the battery. Choose a battery that is shielded from drafts or sunlight by other batteries or by the battery shelter. DO NOT immerse the sensor directly in the battery's electrolyte, it will be severely damaged. Temperature compensation of charging voltage is now automatic.

S E T T I N G S / A D J U S T M E N T S

ADJUSTABLE CHARGE TERMINATION SET-POINTS - ("Charge Set-Point"): Four different charge termination voltage set-points are available with this switch.

The control is factory set at position B. To change the set-point, locate the adjustment switch on the front panel. Using a slotted screwdriver, turn the switch until the slot is pointing at the desired position.

If problems develop, refer to the "TROUBLE SHOOTING" section of this book.

Table 1 : Charge termination set-points by switch position (± 2%)

CONTROL VOLTAGE	SWITCH POSITION A	B	C	D
12 VOLT	15.3	14.8	14.3	13.8
24 VOLT	30.6	29.6	28.6	27.6
36 VOLT	45.9	44.4	42.9	41.4
48 VOLT	61.2	59.2	57.2	55.2

LOW-VOLTAGE LOAD DISCONNECT (LVD) SETTINGS:

NO LVD - ("OFF"): - For an override of the load disconnect function, push the switch up. No load disconnect will occur with the switch in the "OFF" position.

AUTOMATIC LVD - ("NORM"): - When the "Load Disconnect" switch is in the "NORM" position, the load control circuit will operate automatically. Refer to the "OPERATION : LOW-VOLTAGE DISCONNECT" section for a description of this operation. If a load disconnect occurs, the loads will be automatically reconnected when the batteries charge up to the Load Reconnect voltage, or they can be reconnected manually by using the "RESET" position.

MANUAL RESET - ("RESET"): - For a temporary load reset, push the switch down. The battery voltage must remain above the Load Disconnect voltage for the load to stay connected after reset.

ADJUSTING LVD SET-POINTS - ("Load Disconnect Adjust"): The Load Disconnect and Reconnect set-points are factory set as listed in the specifications section, and are adjustable. To alter the voltage at which the load disconnect and reconnect occur, turn the adjustment pot on the front of the unit labeled "Load Disconnect Adjust" clockwise to decrease and counter-clockwise to increase *(for the range of adjustment, refer to the specifications section: "Load Disconnect Adjustment Range*"). Both set-points will change, with the span value fixed.

NOTE : When adjusting this control, it is important to use the proper size screwdriver. Do not force the adjustment beyond the end stops, it will damage the control.

If problems develop, refer to the "TROUBLE SHOOTING" section of this book.

O P E R A T I O N

CHARGE REGULATION (12 and 24 volt units): The two-step control circuit regulates the charging of storage batteries by monitoring battery and solar panel voltage. **STEP 1: CONSTANT CURRENT (FULL) CHARGE MODE**: At sunrise, the charging relay energizes and closes, connecting the solar panel directly to the battery and lighting the "CHARGE MODE" light. The battery will accept as much current as the solar panel will provide, and battery voltage will rise. **STEP 2: CONSTANT VOLTAGE (FLOAT) CHARGE MODE**: When the battery reaches the full charge termination voltage, the charging relay will open and the "CHARGE MODE" light will go out. At this point the float controller takes over to keep the battery below the float voltage and supply limited current (maximum float current). As the battery approaches the float voltage, the current will taper off, eventually falling to the battery's maintenance current.

CHARGE REGULATION (36 and 48 volt units): The operation of a 36 and 48 volts unit is identical with the exception that no float circuit is included.

MAXIMUM SOLAR PANEL USAGE : If a load is applied when the charger is in the float mode, the controller will supply up to its maximum float current to maintain the battery charge. If the load is less than the maximum float current the batteries will still be receiving a net charge from the float controller. If the load current is more, the battery will supply what the float controller cannot and the battery voltage will fall. When it falls below the full charge resumption voltage, the charging relay will re-close, re-initiating the full charge mode. This insures that if a large load is applied during the day, maximum use will be made of the power available from the solar panel.

LOW-VOLTAGE DISCONNECT : The low-voltage disconnect (LVD) of the PPC prevents damage from deep discharge of the batteries by automatically disconnecting the loads. The disconnect threshold is load current compensated by a factor of 10 mv/amp, and a minimum time of 3 seconds is applied to prevent false disconnect. When a disconnect occurs, the load relay is energized and opens, and a red L.E.D. "LOAD DISCONNECTED", visible on the front panel, will light to indicate that the loads have been disconnected. Normal battery charging will continue. When the battery voltage rises to the reconnect threshold, the loads will automatically be reconnected to the battery and the red L.E.D. will go off. The LVD function has a reset/disable switch and user adjustable set-points.

Note: The amount of time required to recharge the battery sufficiently to reconnect the loads depends upon the battery size, solar panel current and weather conditions. In some cases, it can take several days or longer. The loads can be manually reset prior to the reconnect voltage by pressing the "MANUAL RESET" switch.

REVERSE CURRENT PROTECTION : The PPC uses a timing circuit to disconnect the solar panel from the battery at night, preventing reverse leakage current loses through the solar panel. About 12 hours after sunrise the charging relay will open. If the battery is below the reconnect threshold and voltage is still available from the solar panel, the relay will re-close and continue charging. It will open again about every 2 hours thereafter to determine if power is still available for charging. The relay will stay open after the 12 hour period if the battery is above the reconnect threshold or if there is no power available from the solar panel. This

results in the relay being open every night. Note: The relay may be closed ("Charging" light on) for a few hours in the evening after the sun has gone down.

M O N I T O R I N G

"CHARGE MODE" LIGHT: The "Charge Mode" light will be on when the controller is in the full charge mode. In this mode, the charging relay is closed, connecting the array directly to the battery. This light should go on first thing in the morning, and will go off if the battery reaches the "Full Charge Termination" set-point. If the light is off after morning, the batteries have reached the full charge voltage some time that day. The light may go on again if the battery drops below the reconnect voltage and the controller goes into the full charge mode again. It is not uncommon for the light to remain on, for several hours after dark. *Refer to the OPERATION section "CHARGE REGULATION" for details on controller operation.*

"LOAD DISCONNECT" LIGHT: When the "LOAD DISCONNECT" light is on, the LVD circuit is activated and any DC loads connected to the "Load" terminals will be disconnected. This occurs at the LVD set-point voltage. The light will go out when the voltage rises above the reconnect voltage and the load is reconnected automatically, or if the reset switch is pushed to LVD "RESET" or LVD "OFF". *Refer to the OPERATION section "LOW-VOLTAGE DISCONNECT" for details on LVD operation*.

BATTERY / ARRAY METERS - These meters have an accuracy of 5% of full scale, which means the voltage reading may be off by .75 volts (for a 12 volt unit), and the current by 1.5 amps. These meters are intended only as an **INDICATION** of system condition, like a gas gauge on a car, and **NOT** as an accurate measurement. For more precise measurements, a separate meter with higher accuracy is advisable.

"BATTERY" METER: This meter reads battery voltage. The battery voltage is a general indication of battery condition, or capacity.

GREEN: The battery is charged or in good condition.

YELLOW: Usage should be more conservative.

RED: Usage should be limited and other sources of charging used if available.

"ARRAY" METER: This meter indicates the amount of current the solar panel is generating. Consult the panel supplier or literature for rated output to see what the output should be under ideal conditions (bright sunny day, panel aimed right at the sun, no shadows or dirt on the panel) for the total number of panels in the system. Any current will be used first to operate any loads that are on, with the balance going into the battery for charging. The current meter can be used to optimize the array tilt angle by moving the array (if possible) and noting when current is maximum.

F U S E / C I R C U I T B R E A K E R

"ARRAY FUSE" - An array fuse is included for the 30 amp PPC. (Not available on 50 amp units (Option P)). This will protect the controller from over-current from the solar panels or a short circuit at the array. Replacement is a 30 amp AGC fuse.

"LOAD PROTECTOR" - A load circuit breaker is included with the PPC. This provides over-current protection for the load circuit (PPC and load connections) and provides protection from a short circuit at the load. This also can be used as an on/off switch for the load.

O P T I O N S

NOTE : Options cannot be added to units after production. Some of the features and functions described in this manual are not included on all of the units.

OPTION M - OUTDOOR ENCLOSURE (NEMA 4X with Clear Door)

This enclosure is intended for use indoors or outdoors for watertight, dust tight and corrosion-resistant applications and provides a clear door for viewing metering and status lights without opening the enclosure.

OPTION P - 50 AMP CHARGE CURRENT

This option provides 50 amps of charging current capabilities. The terminal accept up to 6 AWG wire. Load ratings remain as stated in the specifications.

T R O U B L E S H O O T I N G : G E N E R A L N O T E S

IF THE CONTROLLER IS NEWLY INSTALLED, CHECK THESE THINGS FIRST:

1) Re-check system wiring to insure proper installation and polarity .
2) Check all system fuses and circuit breakers. Before replacing a blown fuse, locate and correct the cause.
3) Check to be sure that there is a connection (voltage input) to the "BATTERY SENSE" terminals from the battery. This would be either a factory installed jumper strip on the controller terminal block from the "BATTERY SENSE" terminals to the "BATTERY" terminals, or a connection from the sense terminals directly to the battery itself.
4) Check to see that modules and batteries are in the correct series-parallel configuration for proper system voltage and current.
5) Review controller specifications relating to array output, load ratings and system sizing to insure that ratings are not exceeded.
6) Review the controller specifications relating to operation and set-points, particularly the charge termination and reconnect voltage set-points. If possible, check this with the operation of the controller, monitoring the battery voltage with a multi-meter.
7) Some types of loads (fluorescent lights, inverters) can generate electronic "noise" that sometimes interferes with the operation of the controller. Check to see if strange behavior can be traced to operation of a certain appliance.
8) Inspect the temperature compensation sensor and sensor wire. Check for a broker sensor or a cut or frayed sensor wire.
9) If possible, perform the "FIELD TEST PROCEDURE" and /or "BENCH TEST PROCEDURE" that follows.
10) The colored scale volt meters that the PPC is equipped with are 5% accurate (about .5 volt in a 12 volt system) and are designed to give a general state of charge, not to determine voltages accurately.

IF THE CONTROLLER HAS BEEN INSTALLED AND WORKING PROPERLY FOR AWHILE, CHECK THESE THINGS FIRST:

11) Check all system fuses and circuit breakers. Before replacing a blown fuse, locate and correct the cause.
12) Confirm that all connections are clean and tight. Particularly check crimp connections that have been crimped but not soldered as these connections tend to deteriorate over time.
13) Some types of loads (fluorescent lights, inverters) can generate electronic "noise" that sometimes interferes with the operation of the controller. Check to see if strange behavior can be traced to operation of a certain appliance.
14) If you have an accurate digital volt meter, check for voltage drop between the controller and the battery by measuring voltage at the battery and at the controller when maximum charging is occurring. Drops often occur through old fuses, fuse holders or circuit breaker boxes and at loose or corroded connections.
15) High voltage from nearby lightning strikes or unregulated charging sources can damage the controller. The built-in lightning protection provides substantial protection, but it is sometimes overwhelmed.
16) Inspect the temperature compensation sensor and sensor wire. Check for a broker sensor or a cut or frayed sensor wire.
17) Check output from the array, and that it is not partially shaded or dirty.
18) If possible, perform the "FIELD TEST PROCEDURE" and /or "BENCH TEST PROCEDURE" that follows.

P R O B L E M D E S C R I P T I O N S

BATTERY UNDER CHARGED

CONTROLLER NOT CHARGING AT ALL, ALWAYS IN THE FLOAT MODE ("CHARGE MODE" LIGHT OFF)

Check to see that the controller is receiving voltage (at least about nominal system voltage) from the battery and the solar panels. If it is, momentarily disconnect and reconnect the panels, using an array disconnect switch (if included with your system). The controller should reset into the full charge mode ("CHARGE MODE" light on). If it does not reset, the controller may be defective.

See General Note #8 above. A damaged sensor or wire will cause the controller to malfunction.

CONTROLLER STOPS CHARGING TOO SOON, AT TOO LOW A VOLTAGE

See General Note #6 above: Try to monitor the voltage at the "BATTERY SENSE" terminals when the controller actually switches. Most often, when a controller is operational, it is switching the correct voltage. If the battery is not reaching the charge termination set-point voltage before the controller switches, it is usually an error in the voltage that the controller is sensing, not a controller failure.

See General Notes #12 and 14 above: A poor connection between the battery and the controller results in a voltage drop during charging periods (larger drop for higher current) that disappears when charging stops. This voltage drop results in a higher voltage being sensed at the controller than is actually at the battery.

CONTROLLER CLICKS AND CHATTERS, PARTICULARLY IN THE MORNING AND EVENING

See General Notes #12 and 14 above: Check the connection to the battery. A poor connection at the battery will cause the relay to chatter under low light conditions and the controller to remain in float mode during full sun.

CONTROLLER NOT CHARGING, "CHARGE MODE" LIGHT DIM, BATTERY VOLTAGE VERY LOW

See LVD trouble shooting section (below). If the LVD circuit is not operating, the battery can be discharged to a very low voltage. If the battery is extremely low, there might not be enough voltage to operate the controller. The charging relay requires a minimum operating voltage to engage and allow charging. If the battery is down to 9 volts or lower on a 12 volt system, (17 on a 24 volt) connect the battery directly to the array (or use an auxiliary charging source) until sufficient charging has occurred to increase the voltage.

Note: Battery life depends on the number, time and the depth of the discharges. Severe battery damage can result when batteries are deeply discharged and not recharged immediately.

"CHARGE MODE" LIGHT ON AT NIGHT

Review the "REVERSE CURRENT PROTECTION" and "POWER CONNECT SEQUENCE" sections of this manual. The reverse leakage timer may cause the "Charge Mode" light to be on for a few hours each evening. Also, the light will stay on during the night of the first day of

installation or if the array has been manually disconnected that day. If the light stays on all night every night, the timer may be defective.

BATTERY OVERCHARGING

CONTROLLER ALWAYS IN FULL CHARGE ("CHARGE MODE" LIGHT ON)

See General Note #6 above: The battery may not be reaching the charge termination set-point.

See General Note #3 above: No voltage at the battery sense terminals tells the controller that the battery voltage is low and needs to be charged more. Install a connection from battery to "BATTERY SENSE" terminals to resolve.

See General Note #8 above: A damaged temperature sensor or wire will cause the controller to malfunction and requires immediate replacement.

CONTROLLER NOT IN CHARGE MODE ("CHARGE MODE" LIGHT OFF)

Disconnect array, then reconnect. Listen for relay to click and for “Charge Mode" light to come back on. If the light goes on but you hear no click, the relay or controller may be defective.

Check for other charging sources that are not properly regulated, causing the battery to overcharge.

LOAD DISCONNECT (LVD) CIRCUIT NOT OPERATING CORRECTLY

LOADS ALWAYS DISCONNECTED, LVD LIGHT ON, EVEN WHEN BATTERY VOLTAGE IS HIGH

See General Note #6 above: No voltage at the battery sense terminals tells the controller that the battery voltage is low and loads need to be disconnected. Install a connection from the battery to "BATTERY SENSE" terminals to resolve.

LOADS DISCONNECTED TOO SOON OR NOT RECONNECTING

See General Note #4 above: The battery may not be reaching the reconnect voltage set-point.

See General Notes #12 and 14 above: A poor connection between the controller and the battery results in a voltage drop when heavy loads are turned on that disappears when the loads are turned off. The heavier the loads are, the larger the voltage drop will be. This voltage drop results in the controller seeing a lower voltage than what the battery voltage actually is.

LOADS NOT DISCONNECTING ON LOW VOLTAGE, LVD LIGHT OFF

Check the position of the "LVD" switch. If the switch is in the "OFF" position the load will not be disconnected.

LOADS ALWAYS DISCONNECTED, LVD LIGHT OFF, BATTERY VOLTAGE IS HIGH

Check the load circuit breaker on the front of the controller. If the breaker is tripped, the load will not operate.

F I E L D T E S T P R O C E D U R E : P P C

Test equipment required: Digital Multimeter
Conditions: Sunny or bright overcast if possible

This procedure assumes that the solar panels are installed and operational and capable of producing at least 17.5 volts open circuit (for a 12 volt system). Proportionately higher for higher voltage systems. Systems should be equipped with disconnects or switches to facilitate connecting and disconnecting the batteries and solar panel as described in this procedure. If performing this procedure without approved disconnects, care should be taken since arcing may occur. On bright days it ma y be advisable to partially cover the solar panel to reduce the current produced.

Warning: Most batteries produce hydrogen gas when charging, which is extremely explosive. Avoid making sparks in the vicinity of batteries and provide adequate battery ventilation.

All measurements described in this procedure should be made at the controller terminals.

1) Disconnect Load(+), Array(+), Battery(+), and Battery Sense(+)(jumper or wire) from the controller. Secure each wire away from any possible contact with other wires, metal chassis, enclosures etc.
2) Measure the resistance between the Battery(+) and Solar Panel(+) terminals on the controller. It should be open (more than 10M ohm). Turn on load circuit breaker and measure the resistance between Load(+) and Battery(+). It should be less than 1 ohm. Turn off load circuit breaker and re-measure. It should be open.
3) Reconnect the solar panel to the controller. (On 36 volt or 48 volt chargers, briefly connect a jumper wire between Solar Panel(+) and Battery(+). When the charge light comes on, remove the jumper).The charge light should go on, and after a few moments the load disconnected light should come on.
4) Measure the voltage between Solar Panel(+) and Solar Panel(-). It must be at least 17.5 volts for a 12 volt system (proportionately higher for higher voltage systems).
5) Measure the voltage between Battery(+) and Battery(-). It should be the same as the voltage measured in step 4.
6) Turn on load circuit breaker and measure the voltage between Load(+) and Load(-). It should be zero.
7) For 12 volt or 24 volt chargers, go to step 8. For 36 volt or 48 volt chargers, install a jumper wire between Battery(+) and Solar Panel(+) then go to step 8.
8) Install a jumper between Battery(+) and Battery Sense(+). The charge mode light should turn off. Move the LVD switch to manual reset and observe that the load disconnected light turns off. Note: A few seconds after the jumper is installed, the LVD will automatically reset. If this happens before you test the manual reset, remove the jumper, wait for the light to come on, reinstall the jumper and try the switch again.
9) For 12 volt and 24 volt chargers only; Measure the voltage between Battery(+) and Battery(-). It should be approximately equal to the float voltage. (Refer to the Specifications for actual values.)
10) If the controller fails any of these tests it is defective. If all tests are passed, the problem is most likely elsewhere in the system.

B E N C H T E S T P R O C E D U R E : P P C

Test equipment required: Digital Multimeter, Adjustable Power supply

Nominal Voltage	Power Supply Range
12	10-18 Vdc
24	20-36 Vdc
36	30-48 Vdc
48	40-64 Vdc

All measurements described in this procedure should be made at the controller terminals.

1) Make sure that there is a jumper between Battery(+) and Battery Voltage Sense(+) and one between Battery(-) and Battery Voltage Sense(-).
2) Check continuity between Battery(-),Solar Panel(-) and Load(-).
3) Turn off the load circuit breaker and measure the resistance between Load(+) and Battery(+). It should be open (more than 10M ohm). Turn on the load circuit breaker and re-measure. It should be less than 0.2 ohm.
4) Measure the resistance between Solar Panel(+) and Battery(+). It should be open.
5) Set the power supply to the nominal system voltage. Connect the power supply negative to the controller Battery(-) terminal. Connect the power supply positive to the controller Solar Panel(+) terminal. For 36 volt and 48 volt chargers, briefly connect a jumper between Solar Panel(+) and Battery(+). When the charge mode light turns on, remove the jumper.
6) Verify that the charge mode light is on. Measure and note the voltage between Solar Panel(+) and Solar Panel(-).
7) Measure the voltage between Battery(+) and Battery(-). It should be the same as the voltage measured in step 6 to within +/- 0.1 Volt. Measure the voltage between Load(+) and Load(-). It should be the same as the voltage measured in step 6 to within +/- 0.1 Volt.
8) Install a jumper between Battery(+) and Solar Panel(+).
9) Verify the charge termination and charge resumption set-points by changing the power supply voltage up and down and observing the activation of the charge mode light.
10) Set the LVD switch to AUTO LVD. Verify the load disconnect and load reconnect set-points by changing the power supply voltage up and down and observing the activation of the load disconnected light. There is a time delay on the load disconnect circuit. The set-points must be approached slowly to avoid overshooting. With the controller in the load disconnected mode, press the MANUAL RESET and verify that the light goes off momentarily. Set the LVD switch to NO LVD and verify that the load disconnect does not activate.
11) For 12 and 24 Volt chargers only; remove the jumper between Battery(+) and Solar Panel(+). Increase the power supply voltage to 18 volts for a 12 volt system or 36 volts for a 24 volt system. Measure the voltage between Battery(+) and Battery(-). It should be about the float voltage.

LIMITED FIVE YEAR WARRANTY
SPECIALTY CONCEPTS, INC.

1. Specialty Concepts, Inc. warrants all its products for a period of five (5) years from the date of shipment from its factory. This warranty is valid against defects in materials and workmanship for the five (5) year warranty period. It is not valid against defects resulting from, but not limited to:
   A. Misuse and/or abuse, neglect or accident.
   B. Exceeding the unit's design limits.
   C. Improper installation, including, but not limited to, improper environmental protection and improper hook-up.
   D. Acts of God, including lightning, floods, earthquakes, fire and high winds.
   E. Damage in handling, including damage encountered during shipment.
2. This warranty shall be considered void if the warranted product is in anyway opened or altered. The warranty will be void if any eyelet, rivets, or other fasteners used to seal the unit are removed or altered, or if the unit's serial number is in any way removed, altered, replaced, defaced or rendered illegible.
3. The five (5) year term of this warranty does not apply to equipment where another manufacturers' warranty is available. An example of such equipment may be, but is not limited to, an electronic enclosure. The time limit for this warranty may be for less than the Specialty Concepts limited warranty. Specialty Concepts will assist the claimant in attempts to seek warranty claims for such equipment, where appropriate.
4. Specialty Concepts cannot assume responsibility for any damages to any system components used in conjunction with Specialty Concepts products nor for claims for personal injury or property damage resulting from the use of Specialty Concepts' products or the improper operation thereof or consequential damages arising from the products or use of the products.
5. Specialty Concepts cannot guaranty compatibility of its products with other components used in conjunction with Specialty Concepts products, including, but not limited to, solar modules, batteries, and system interconnects, and such loads as inverters, transmitters, and other loads which produce "noise" or electromagnetic interference, in excess of the levels to which Specialty Concepts products are compatible.
6. Warranty repair and/or evaluation will be provided only at Chatsworth, California facility of Specialty Concepts. Units for such repair and/or evaluation must be returned freight prepaid to Specialty Concepts with a written description of any apparent defects. Specialty Concepts will not be required at any time to visit the installation site wherein Specialty Concepts' products are subject to warranty repair and/or evaluation.
7. Only Specialty Concepts is authorized to repair any of its products, and they reserve the right to repair or replace any unit returned for warranty repair. The party returning a unit for repair is responsible for proper packaging and for shipping and insurance charges, as well as any other charges encountered, in shipping to and from Specialty Concepts.
8. This warranty supersedes all other warranties and may only be modified by statement in writing, signed by Specialty Concepts.

Warranty terms effective as of April 1, 1993

REPAIR INFORMATION

Directions for returning units needing repair.

1. Write up a note with the following information:
   Name / Company Name
   Return Address : (For USA/Canada: UPS Deliverable. Avoid PO Boxes)
   Daytime Phone
   Description the failure
   Specify amount of repair charges pre-approved (we will contact you if repair charges are larger than this amount.)
2. Box up unit with copy of sales receipt (if available).
3. Send by UPS or Parcel Post to :

Specialty Concepts, Inc.
Attn : Repair Dept.
8954 Mason Ave
Chatsworth, CA 91311 USA

If the Repair is not covered under warranty, the repair charges will not exceed 30% of the value of a new unit (shipping and handling not included). Domestic charges are collected via UPS-COD.
For non-warranty repairs, repaired portion features an additional one-year warranty.

SPECIALTY CONCEPTS, INC.
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