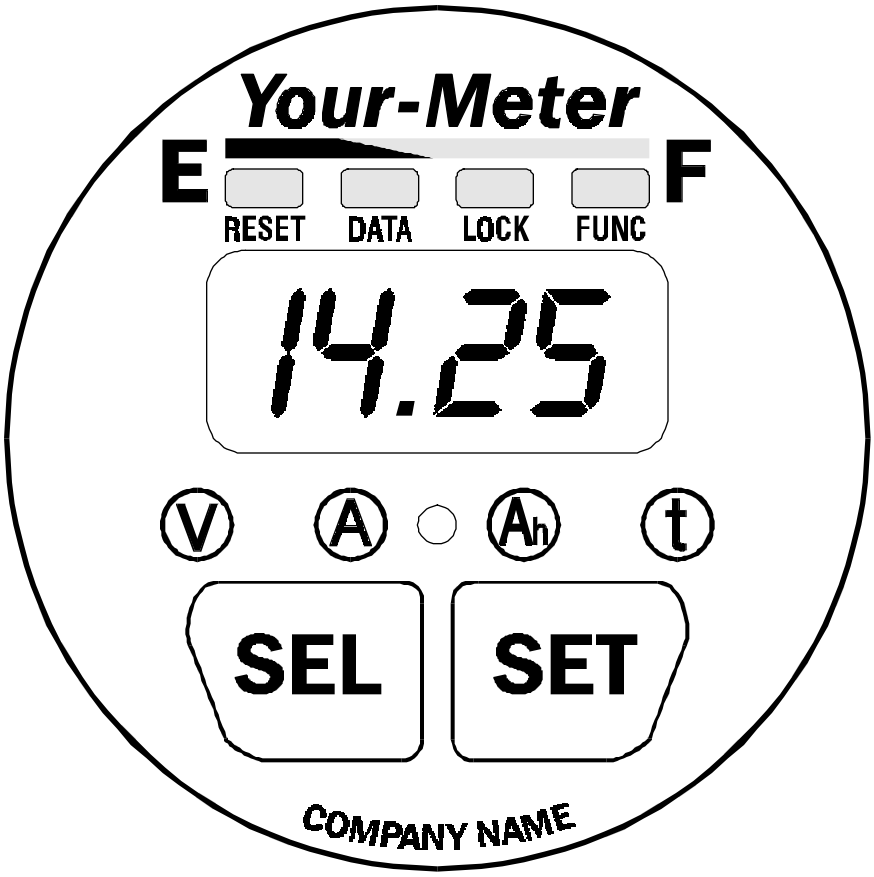
Owner's Manual

 Manual Part # 890015 Rev. 4 *6/1/96*



Graphic and Digital Displays!

Ideal battery monitor for...

...Marine Systems
...Alternative Energy Systems
...Recreational Vehicle Systems
...Industrial Lift Truck Applications
...Electric Vehicles and many more!

The world's most accurate state-of-charge monitor!

Specifications

Voltage: **For 12V and 24V battery systems. Prescaler required for hgher voltages.**

Ⓥ **Standard Model:** Two Auto-ranges: 0 to 19.95V (0.05V resolution)
20.0 to 50.0V (0.1V resolution)

Optional Prescalers: 0-100V, 0-500V (Used with standard model)

Amperage:

Ⓐ **Low Range:** ± 0 - 40.0 Amps (0.1 Amp resolution)

High Range: ± 500 Amps (1 Amp resolution)

Amp-Hours:

Ah **Low Range:** ±0 - 199.9 Amp-Hours (0.1 Amp-Hour resolution)

High Range: ± 200 - 1999 Amp-Hours (1 Amp-Hour resolution)

Time Remaining:

t **Low Range:** 0 to 199.9 Hours (0.1 hour resolution)

High Range: 0 to 255 Hours (1.0 hour resolution)

Power Requirements:

9.5-40 Volts DC

Current: 50-150 mA (Depends on Ambient light. Display Auto Dims.)
28 mA (Sleep Mode - Bar Graph Display Only)

Shunt type required: 50 mV @ 500 Amp

Accuracy:

Voltage: ± (0.6% of reading + 1 least count of resolution)

Amperage: ± (0.8% of reading + 1 least count of resolution)

Amp-Hours: Ahr Error ≃ (Time of measurement x current error)

Physical:

Max. Outer Bezel Diameter: 2.5 inches (63.5mm)

Max. Barrel diameter: 1.95" (50mm)

Max. Depth: (from back of bezel) 3.15 inches (80mm)

Hole Cutout Size: Use 2" or 2 1/16" hole saw (52mm)

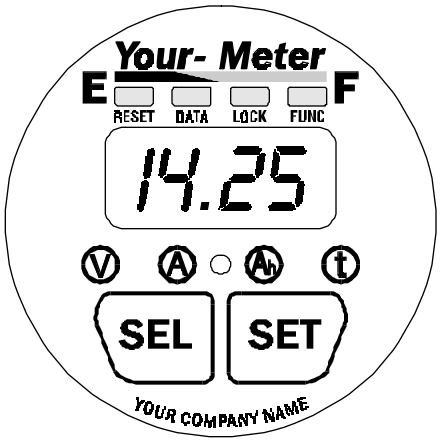
Water Resistance: Splashproof front panel.

Weight: 8 Ounces (227g)

Operation

Although Your Meter is a very sophisticated device, obtaining basic battery information from it is simple. With the unit turned on and the Ⓥ (**V**olts) LED on, let's learn how to display the four most important DC system parameters .

When you touch the SEL button, you are ***SEL***ecting the display you wish. Each time you touch ***SEL*** in normal operation, you will toggle to the next item to the right Ⓥ (Volts) goes to Ⓐ (**A**mps) to Ⓐh (**A**mp-**h**ours) to Ⓣ (**t**ime).



Now press ***SEL*** to bring up these functions.

Ⓥ **Volts** is the electric *potential to do work*. Voltage is useful to assess the approximate state-of-charge and to check for proper charging. Examples: An at rest, fully charged battery will show about 12.8V. A 12 V battery is 100% discharged when it reachs 10.5Volts with a 20 hr. rated load applied. A typical charging voltage would be 14.2V.

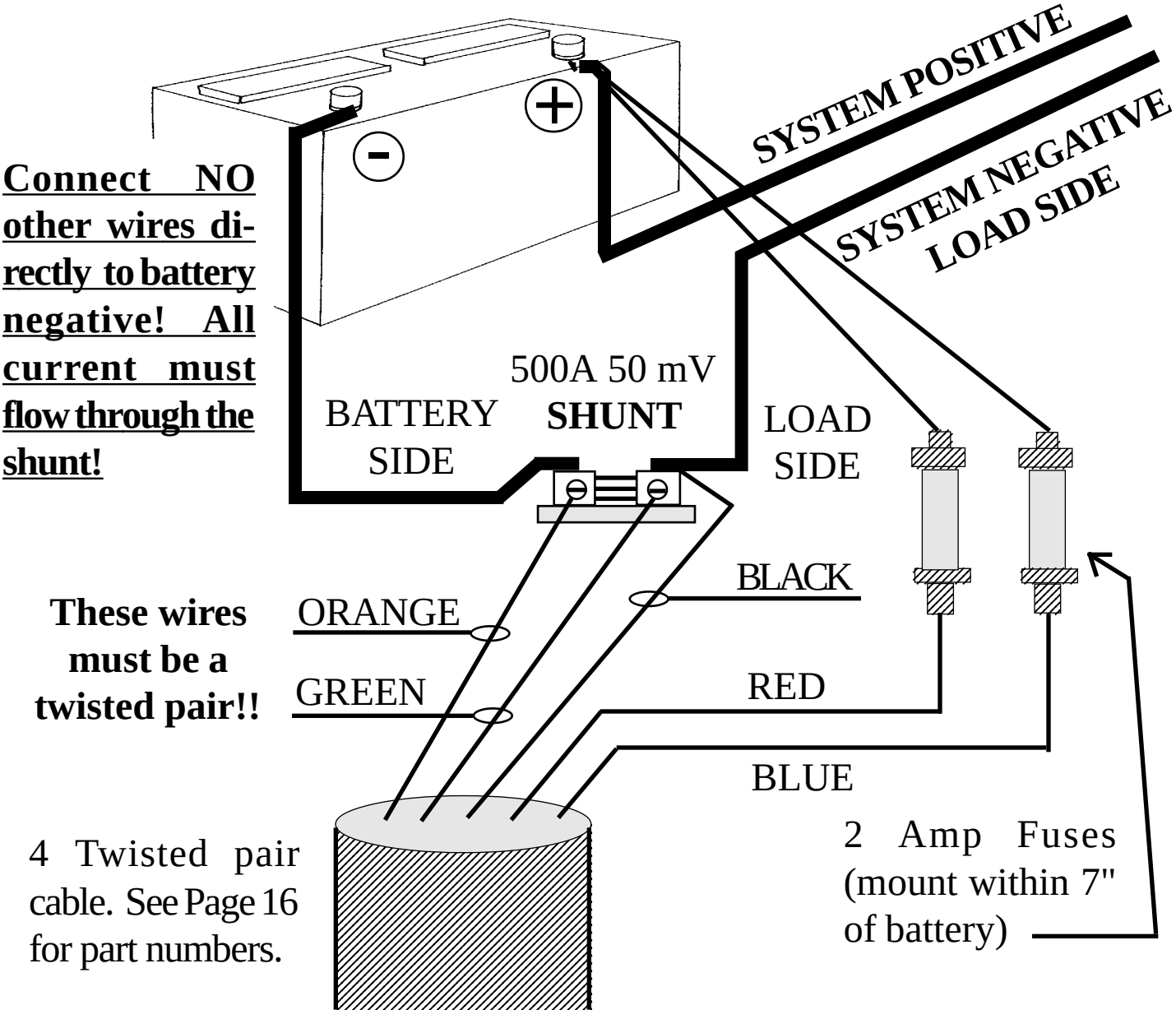
Ⓐ **Amps** is the present *flow* of current in or out of the battery. For example, a refrigerator may draw 6 Amps of current. This is displayed as `- 6.0` (6 amps are being *consumed*). Discharge is shown as a negative number and charging is shown as a positive number (unsigned).

Ⓐh **Amp-hours** consumed represents the *amount of energy removed from* the battery. If you run a 10 Amp load for one hour then ten Amp-hours are consumed. Your Meter will show `-10` in the Ⓐh display. During chargingYour Meter will compensate for charging efficiency and count back up toward `0` .

Ⓣ **Time** is an estimate of how long (in hours) the battery will sustain a load. It is based on a selectable, time averaged, rate of discharge. Default is the average of the last four minutes of use. (See Page 23)

Shunt & Battery Wires

The shunt is the current sensor for Your Meter. Its 500A 50mV rating means that when 500 Amps flows through it there is 50mV generated across it. The millivolt signal is translated into an Amps display in the meter. For example: A 50A load would generate 5mV across the shunt and would be displayed as 50 Amps. **Caution:** In the diagram below, the **darker wires** represent primary wiring and should be able to carry full battery load current. Size appropriately!

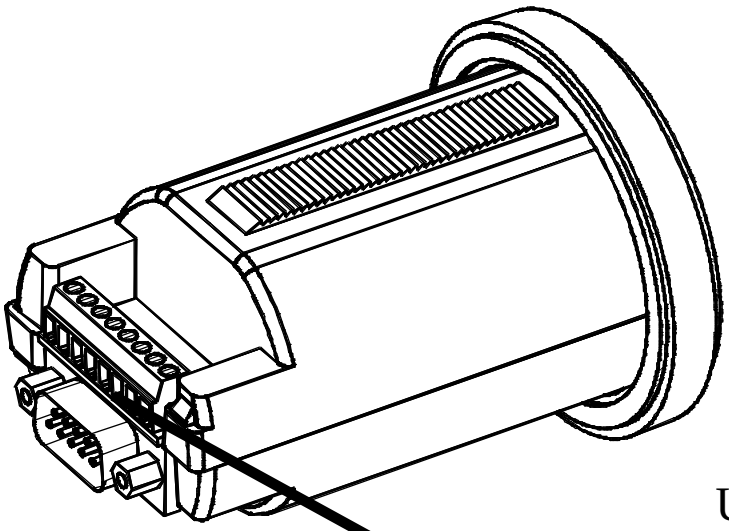


Meter Wiring Detail

Make the necessary wire connections to Your Meter as shown in the following diagram:

Color code shown for CECO 4 twisted pair cable. Part #s below:

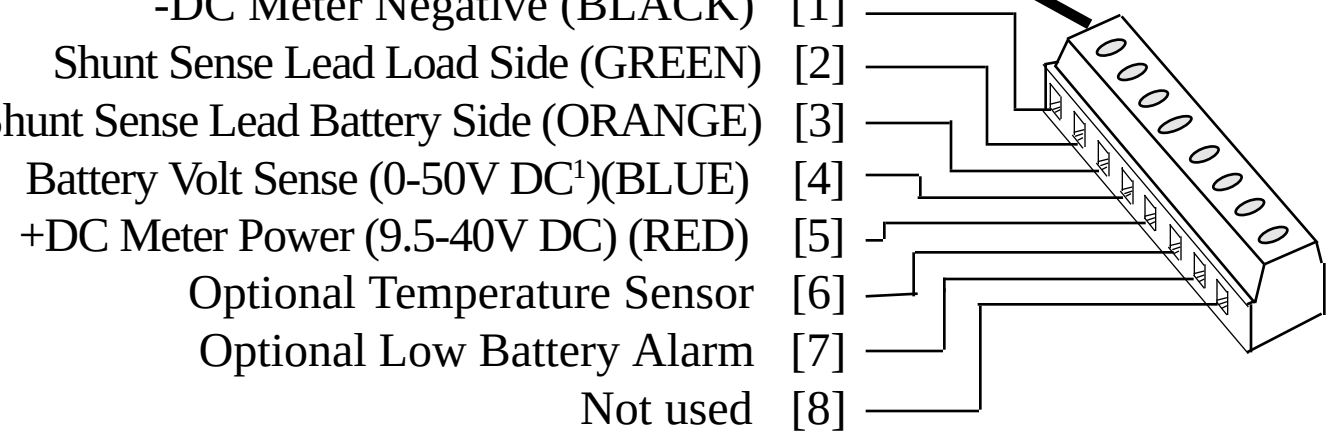
PN 910007 -15'
PN 910009 -25'
PN 910010 -50'



CAUTION

Use correct sized screwdriver for terminal screws. Tighten firmly but do not over-tighten to avoid damage

Top Rear View



-DC Meter Negative (BLACK) [1]
Shunt Sense Lead Load Side (GREEN) [2]
Shunt Sense Lead Battery Side (ORANGE) [3]
Battery Volt Sense (0-50V DC[1])(BLUE) [4]
+DC Meter Power (9.5-40V DC) (RED) [5]
Optional Temperature Sensor [6]
Optional Low Battery Alarm [7]
Not used [8]

1) For Voltages above 50V a Pre-Scaler must be used. See Options and Accessories Manual which supplied only if you have ordered an option.

Setting Battery Capacity

The first time you use Your Meter, it assumes you have 200 Amp-hour lead acid batteries. If your battery capacity is different you must change the declared battery capacity. Follow these instructions to declare a new capacity:

A. Press and hold the **SET** button for 3 seconds to enter SET UP (and Advanced Functions) menu. SEL appears in the display. Press **SEL** and notice that the green Ⓥ LED is on.

B. Press **SEL** again and note that the Ⓐ light comes on. Press again and now the Ⓐh LED is on and 200 appears in the display. This is the default battery capacity.

C. Now press and hold the **SET** button to scroll through battery size options. The display will show 1 Amp-hour increments from 10-40 Amp-hours of capacity, 5 Amp-hour steps from 40-100 Amp-hours capacity and 20 Amp-hour steps over 100 Amp-hours of capacity. If you continue to hold **SET**, after 4 increments the display scrolls faster. When the value you want appears, release the **SET** button. If you overshoot your capacity you will have to scroll all the way to 1980 Ahrs after which the display will roll over and begin scrolling up starting from 10 Amp-hours. NOTE: Versions of Your Meter prior to serial number 05000 increment only in 20 Amp-hour steps from 20 - 1980 Amp-hours .

D. After 10 seconds the meter exits the Set Up mode and the selected value is stored as the new battery capacity and the display returns to Ⓥ (Volts).

Tip: All SET UP and ADVANCED FUNCTIONS begin with the **SET** button. SET UP is normally done at installation. The **SET** button may be **LOCK**ed to prevent unauthorized personnel from tampering with the **SET** functions. See "LOCK" on Page 25.

Setting Up ⓣ

There are four different ways that Your Meter can calculate the time of operation remaining. You may select present consumption level, a four minute rolling average, a sixteen minute, or a 32 minute rolling average.Which method is best for you depends on your installation. Most installations will find the four minute average appropriate. To SET UP ⓣ follow the procedure outlined on Page 19. As you press the **SET** button the following values will appear, use the table below to choose the appropriate averaging period.

Instantaneous: Time Remaining Set Up Display: 000

4 Minute Average: Time Remaining Set Up Display: 001

16 Minute Average: Time Remaining Set Up Display: 002

32 Minute Average: Time Remaining Set Up Display: 003

Operating Tip: Use the longest period of time you can to insure long term load variations are considered. If you want instant feedback, use the instantaneous display (no averaging) 000 display.

Caution: The time of operation display is an estimate of how long your battery can sustain a load. Wild variations in battery current, erroneously declared battery capacity, Peukert's exponent, temperature, and prior charge and discharge history may affect the accuracy of this estimate. Please use this display only as a guide. Remember Your Meter provides you with several important battery parameters. Using all of them, i.e. Voltage, Current, Amp-Hours consumed, and Time remaining should allow you to make an informed decision about the state-charge-of your battery. Do not rely on a single value to determine battery status or performance.

Setting Puekert's Exponent

Pages 32-35 of this manual discuss Puekert's equation and its effect on battery capacity. The exponent used in Puekert's equation is critical to the proper operation of the bar graph state-of-charge display and the time remaining function. The default value of Peukert's exponent is 1.25. You may use the techniques described on pages 32 and 33 to calculate the appropriate exponent for your battery or you may use the tables on pages 34 and 35. Follow the instructions below to change your Peukert's exponent.

A. Press and hold the **SET** button for 3 seconds to enter SET UP (and Advanced Functions) menu. SEL appears in the display. Press **SEL** and notice that the green Ⓥ LED is on.

B. Press **SEL** again and note that the Ⓐ light comes on. Continue to press the **SEL** button until the letters F8 appear in the display. This will require eighteen presses of the **SEL** button . The right most LED of the bar graph with the legend **FUNC** under it will be lit.

C. Now press and hold the **SET** button. The default value of 1.25 (or the previously programed value) will appear in the display. The range of values is from 1.0 to 1.50. Holding down the **SET** button will cause the display to increment in 0.01 steps, after 4 increments the display scrolls faster. When the value you want appears, release the **SET** button. If you overshoot your capacity you will have to scroll all the way to 1.50 after which the display will roll over to 1.00 and continue incrementing. You also have to scroll all the way through to declare exponents between 1.00 and 1.50.

D. After 10 seconds the meter exits the Set Up mode and the selected value is stored as the new Peukert's exponent and the display returns to Ⓥ (Volts).

Low Voltage

Low Voltage Sleep Mode

If the voltage on terminal #4, the Voltage sense terminal, falls below 10.0 Volts, the meter automatically goes into the sleep mode. The Ⓥ function LED flashes to indicate the voltage is below 10.0V. When the Voltage rises above 10.0V the LED stops flashing. This feature reduces the power consumption of Your Meter which reduces the load on the battery, extending the operating time before the battery is completely dead. Also by reducing the power consumption, the meter is able to operate to a lower voltage without a reset of Amp-Hours. With this feature Your Meter will not reset unless the voltage falls below 9.2V if it falls very fast, or 7.15V if the Voltage drops slowly. **Electric Vehicle Users Note:** The Low Voltage sleep feature is defeated when Advanced Function F13 is used to activate the Voltage scaling to 100V or 500V.

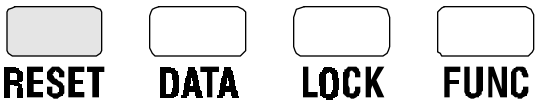
Low Voltage

Power Loss & Reset Annunciation

If the Voltage supplying terminal #5 falls too low an automatic shut down occurs. This voltage varies from a low of 7.2V to about 9.2 Volts depending on how fast the Voltage drops. When power is restored, the display defaults to the Ⓥ function and the digital display flashes. Pressing either the ***SEL or SET*** buttons cancels the flashing display. If the meter is in the sleep mode when power loss occurs, the display will flash for ten minutes and then go to sleep if no buttons are pressed. Once asleep the first button press will wake the display in the flashing mode to annunciate the power loss. The second button press will cancel the flashing display.

Reset and Lock

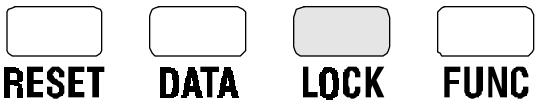
In addition to reporting primary system values, Your Meter is capable of many other front panel functions and will also display important historical battery data. The words below the bar graph display indicate which of these functions you are accessing. To use these functions you must read and understand the following section of this manual.



Resetting Your Meter

RESET Resets Amp-hours to Zero and Resets Your Meter to Factory Values.

To **RESET** the Amp-hour display to Zero, **SEL**ect the **RESET** function as previously described. The letters AH will appear in the display. Press and hold the **SET** button. After 5 seconds the Amp-hour display will be reset to 0 and the letters ALL will appear. If you continue to hold down the **SET** for another 5 seconds all variables and functions are reset to the factory defaults.

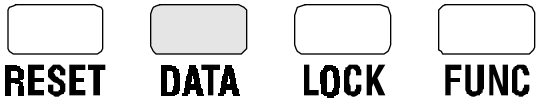


Front Panel Locking

LOCK Prevents user access to Set Up and Advanced Functions.

To **LOCK** Your Meter, **SEL**ect the **LOCK** function as previously described. The letters LOC will appear in the display, indicating you are in the **LOCK** function. Press **SET** and the letters OFF appear indicating the front panel is not Locked. Press **SET** again and the letters ON will appear indicating the front panel is locked. Repeating this procedure toggles the lock off and on, the display will report OFF or ON, indicating Lock off or on.

Historical Data



Key Battery Data Displayed

DATA Key historical battery information is available through this function. Each time the **SEL** button is pressed while in the **DATA** mode the next piece of data is displayed. Select **DATA** as previously described to see **DATA**.

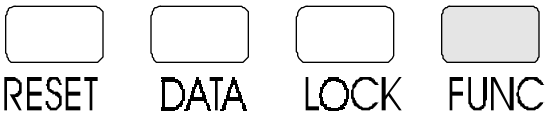
CEF (Displayed as E99): The Charging Efficiency Factor (CEF) is displayed. A display of E99 indicates a 99% CEF. This number sets the rate at which Amp-hours are counted back up during charging. This is an Amp-hour CEF, not Kwhr efficiency. The Default setting is 90%. **NOTE:** If the CEF display has a u in front of it, this means the CEF has been selected by the user. See Advanced Function F06 for details.

#CEF Recalculations(Displayed as **+I999**): This is the number of times that the battery has been discharged more than 10% and then recharged until the Charged Parameters have been met. May be considered as the number of charge/discharge cycles the battery has experienced.

Deepest Discharge(Displayed as **-i999):** Shows the deepest discharge in Amp-hours recorded by the meter since its last **RESET** to factory defaults.

Average Discharge(Displayed as i999): The running average of all discharges as an Amp-Hour value since last **RESET** to factory defaults.

Advanced Functions



Advanced Functions

FUNC Allows setup of Advanced Functions.

To access the **FUNC** mode, **SEL**ect the **FUNC** mode as previously described. The letters F01 will appear in the display and the **FUNC** LED will be lit indicating you are in the **FUNC** mode. Continue pressing the **SEL** button until the function you wish to setup appears. Now press **SET** until the desired value or mode appears. Repeat this procedure until you have setup all of the desired advanced functions. Whatever functions you have setup will become active when the display reverts to its normal mode.

F1 **AUTO DISPLAY SCANNING**

Automatically scans through display with each value displayed for 4 seconds.

DEFAULT: OFF RANGE: OFF or ON

F2 **DISPLAY SLEEP**

Turns off everything except bar graph if there have been no keystrokes for 10 min. Touch **SEL** or **SET** to wake up unit.

DEFAULT: ON RANGE: OFF or ON

F3 **DISPLAY OR SET BATTERY TEMPERATURE**

If there is no external temp sensor and F-16 is OFF (factory default), this function sets ambient battery temperature used to caluculate *rate corrected* battery capacity which drives the LED bar graph and the Time remaining display. Feature not available on units with serial numbers prior to 05000.

DEFAULT: 20C RANGE: 0-40C STEP: 1C

If F-16 is ON and an optional external temperature sensor is connected between Pin 6 and Pin 8 (ground), F-3 will display temperature (0-99 C). Temperature will continue to be displayed until one of the two front panel

buttons is pressed. Active Temperature display is annunciated by the absence of front panel status indicators. If 0 is displayed at normal (~ 20 C) temperatures, an open temperature probe should be assumed. If >99 is displayed at normal temperatures, a shorted probe should be suspected.

F4 **TURN ON KWHRS DISPLAY**

Kilowatt-hours are displayed in the Ah mode. (Note: The Kwhr display does not take into account Charging Efficiency. As a condition for a recalculation of the CEF and an automatic reset of Amp-hours to zero, 100% of the energy removed from the battery must be returned. The number in the Kwhr display must be zero or positive to allow a recalculation of the CEF and an automatic reset to zero. You may use this function to verify that this condition has been met.)

DEFAULT: OFF RANGE: OFF or ON

F5 **USE ALTERNATIVE ENERGY (AE) DEFAULTS**

Changes time to meet Charged Parameters to 1 minute from normal 5 minutes. (Also consider changing Charged Current to 4%)

DEFAULT: OFF RANGE: OFF or ON

F6 **MANUALLY SET CEF (Not Recommended)**

Allows manual set up of CEF. Displayed as two digits. Default display A90 indicates automatic CEF recalculation feature active. Returning to A90 from a user CEF turns the automatic CEF feature back on. If a user set up CEF has been selected it will appear as a UXX in the **DATA** mode. See Page 25.

DEFAULT: A90 RANGE: 65-99 STEP: 1

F7 **SET TEMPERATURE COEFFICIENT**

Compensates for capacity change with temp. ~ 0.5% Cap/°C. This coefficient must be supplied by the battery manufacturer. The default value is typical for lead acid liquid or gelled batteries.

DEFAULT: 0.5 RANGE: .1-0.9 STEP: 0.1

Advanced Functions

F8 **SET PEUKERT EXPONENT**

Sets exponent for Peukert's equation. A setting of 1.0 defeats Peukerts calculation. See *Owner's Manual* pages 32-35 for a discussion of Peukert's equation and typical values for various batteries.

F9 **SET DISCHARGE FLOOR**

Sets the discharge floor used to calculate bar graph status and time of operation remaining functions. The factory default is to calculate time remaining, and bar graph based on a rate corrected discharge of 100% of declared Amp-Hour capacity. In other words, the bar graph will flash red when less than 20% of your rate corrected (Peukert Amp-Hour) capacity remains. Default time remaining is essentially "time till dead battery".

To ensure a margin of safety you may wish to set a different discharge floor. You may wish to set 80% or some other discharge floor for your bar graph.

CAUTION: If you set the discharge floor high, such as 50%, and continue to discharge well beyond this point, you will notice that the bar graph does not "fill up" until you have charged the battery above the discharge floor. In other words, if you set the discharge floor at 50% and discharge 75%, you must recharge back up to the 50% level before your bar graph and time of operation will again give you meaningful information.

DEFAULT: 100% RANGE: 50-100% Step: 5%

F10 - F13 **SEE OPTIONS MANUAL**

F14 **ENABLE LIFT LOCKOUT (Low Battery Contact Line)**

In versions of Your Meter equipped with the Lift Lockout (low battery contact line) Option, this function allows the Lockout to be disabled.

DEFAULT: ON RANGE: ON, OFF

Advanced Functions

F15 **SOFTWARE REV.** Displays revision of software.

Please note that the software changes incorporated in Your Meter now may not be retrofitted into earlier versions of this product. If Your Meter is serial number 005000 or larger, it will come with software version E05 or greater installed. Earlier versions of Your Meter do not support temperature sensing, small Amp-hour increments, separate sensing of meter power and battery voltage, and display 255 instead of CCC when the monitored battery is being charged.

F16 **TEMPERATURE SENSOR ON/OFF**

This function allows you to turn the optional external temperature sensor on or off. This feature is only operable when a temperature sensor has been connected between Pin 6 and Pin 8 of Your Meter. To fully understand this feature, please refer to F3 on pages 4-5 of this document. This feature not available on serial numbers prior to 05000.

DEFAULT: OFF RANGE: ON, OFF

F17 **LIGHT TEST**

This function confirms proper operation of Your Meter's front panel display. When the SET button is pressed in the F-17 mode, the two top left LEDs of the Bar Graph will display Orange/Yellow color, the numeric LED display will report -188.8 and all four FUNCTION indicators will be on. The display returns to normal when the SET button is released. Operation of the two top right (green) LEDs is confirmed when power is initially applied to Your Meter.

DEFAULT: OFF RANGE: ON when SET button is depressed. OFF when SET button is released.

Peukert's Equation

Peukert's Equation describes the effect of different discharge rates on battery capacity. As the discharge rate increases the available battery capacity decreases. The table and examples on the following page illustrate this effect and how to use the table to estimate the exponent "*n*". The tables on pages 34 & 35 have typical values of "*n*" for common batteries.

Making two discharge tests, one at a high discharge rate and one at a low rate, that bracket your normal range of operation, allows you to calculate an "*n*" that will describe this varying effect. Your Meter uses an *"n"* equal to 1.25 which is typical for many batteries.

At some low to moderate discharge rate, typically a battery's 20 hour rate, the logrithmic effect of Peukert's Equation is greatly reduced. The effect of discharge rates smaller than this is nearly linear. Battery manufacturer specifications of battery capacity in Amp-hours is typically given at the 20 hour rate. From this description, if a battery is discharged at this rate for the period of time called out, you will be able to remove the rated capacity.

The equation for Peukert's Capacity (C_p) is:

$$C_p = I^n t \quad \text{where} \quad n = \frac{\log t_2 - \log t_1}{\log I_1 - \log I_2}$$

By doing two discharge tests and knowing I_1 & I_2 (discharge current in Amps of the two tests), and t_1 & t_2 (time in hours for the two tests) you can calculate *n* (the Peukert coefficient). You will need a calculator that has a Log function to solve the equation above. See example on page 35. After you solve for your Peukert's coefficient you may enter it using Advanced Function F8.

Peukert's Equation

The table below may be used to understand the effect of high rates of discharge on available battery capacity. It may also be used to estimate the exponent "*n*" for a battery after a single discharge test. The table is based on a 100 Ahr battery but may be used for any capacity battery by using an appropriately scaled current. See the examples below:

PERCENTAGE OF AVAILABLE CAPACITY FROM A 100 Ahr BATTERY AT DIFFERENT DISCHARGE RATES USING DIFFERENT PEUKERT'S EXPONENTS

		DISCHAGE RATE IN AMPS												
	n	**5**	**10**	**16.7**	**25**	**50**	**75**	**100**	**150**	**200**	**250**	**300**	**400**	**500**
	1	100	100	100	100	100	100	100	100	100	100	100	100	100
EXPONENT	**1.1**	100	93	88	85	79	76	74	71	69	67	66	64	63
	1.2	100	87	78	72	63	58	55	51	48	46	44	42	40
	1.25	100	84	74	67	56	51	47	42	40	37	36	33	32
	1.3	100	81	69	62	50	44	41	36	33	31	30	27	25
	1.4	100	76	61	52	40	34	30	26	23	21	20	17	16
	1.5	100	71	55	45	32	26	22	18	16	14	13	11	10

Example #1: Suppose you have a 200 Ahr battery. Now discharge at a 50 Amp rate until the battery reaches 1.75V per cell (10.5V for a 12V battery). This would be equalivent to a discharge rate of 25A for a 100 Ahr battery. If the battery delivered 67% (134Ahr) the appropriate Peukert's exponent would be 1.25.

Example #2: A 100 Ahr battery with a Peukert's exponent of 1.3 will deliver only 41% of its capacity when supplying a 100A load.