TECHNICAL MANUAL

For
Sun Xtender® Batteries

Manufactured by:

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RECORD OF REVISIONS

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Initial Release	8/26/08
A	10/22/08
B	3/25/09
C	9/09/09

SAFETY SUMMARY

DANGER OF EXPLODING BATTERIES

Lead acid batteries can produce explosive mixtures of hydrogen and oxygen. Take the following precautions:

- Never install batteries in an airtight or sealed enclosure and make sure installation is adequately ventilated.
- Charge batteries in accordance with the instructions given in this manual.
- Keep all sparks, flames and cigarettes away from batteries.
- Connect cables tightly to the terminals to avoid sparks.
- Wear proper eye and face protection when installing and servicing batteries.

DANGER OF CHEMICAL BURNS

Lead acid batteries contain sulphuric acid electrolyte which can cause severe burns to body tissue. Take the following precautions:

- Avoid contact of the electrolyte with skin, eyes or clothing.
- Never remove or damage vent valves.
- In the event of an accident, flush with water and call a physician immediately.

DANGER OF BURNS IF TERMINALS ARE SHORTED

Lead acid batteries are capable of delivering high currents if the external terminals are short circuited. The resulting heat can cause severe burns and is a potential fire hazard. Take the following precautions:

- Do not place metal objects across battery terminals.
- Remove all metallic items such as watches, bracelets and rings when installing or servicing batteries.
- Wear insulating gloves when installing or servicing batteries.
- Use insulating tools when installing or servicing batteries**.**

DANGER OF THERMAL RUNAWAY

Thermal runaway is a condition in which the battery temperature increases rapidly resulting in extreme overheating of the battery. Under rare conditions, the battery can melt, catch on fire, or even explode. Thermal runaway can only occur if the battery is at high ambient temperature and/or the charging voltage is set too high. Take the following precautions:

- Charge batteries in accordance with the instructions given in this manual.
- Do not install batteries near heat sources or in direct sunlight that may artificially elevate their temperature.
- Provide adequate air circulation around the batteries to prevent heat build up.

Table of Contents

Chapter 1 - Introduction
1.1 Company Background 5
1.2 Overview of Sun Xtender® AGM Technology 5
1.3 About this Manual 5

Chapter 2 - Battery Construction
2.1 Component Description 6
2.2 Battery with Cut Away View 8
2.3 Terminal Types 9

Chapter 3 - Technology Comparison
3.1 Sun Xtender® versus Flooded Batteries 10
3.2 Sun Xtender® versus Gel Batteries 11
3.3 Sun Xtender® versus other AGM Batteries 12

Chapter 4 - Battery Specifications
4.1 Battery Models 13
4.2 Terminals 13
4.3 Handles 13
4.4 Definition of Ratings 13
4.5 Temperature Range 13
4.6 UL Recognition 13
4.7 Shipping Classification 13

Chapter 5 - Commissioning and Servicing Instructions
5.1 Storing 14
5.2 Installation 14
5.3 Discharging 18
5.4 Charging 19
5.5 Conditioning 20
5.6 Deep Discharge Recovery 20
5.7 Recycling 20

Chapter 6 - Application Guide
6.1 Load Calculations 21
6.2 Days of Autonomy 22
6.3 Temperature Considerations 22
6.4 Battery Sizing 23

Chapter 7 - Safety Information
7.1 Release of Ignitable Gases 24
7.2 Acid Exposure 24
7.3 Shorting of Terminals 24
7.4 Thermal Runaway 24

Appendix A – Glossary
Appendix B – Frequently Asked Questions
Appendix C – Charts and Graphs

CHAPTER 1 - INTRODUCTION

1.1 Company Background

Concorde Battery Corporation was founded in 1977 and is a manufacturer of premium quality lead acid batteries. Originally, Concorde's main product emphasis was dry charged and gelled electrolyte lead acid batteries. In 1985, Concorde developed its valve regulated, absorbent glass mat [AGM] technology for use in aircraft applications. The success of this technology in the aviation market has been outstanding. Concorde is now the largest manufacturer of valve regulated lead acid batteries for both commercial and military aircraft.

In 1986, Concorde further developed the AGM technology for deep cycle applications. This development effort provided higher energy density (higher capacity) and better cycle life than its gelled electrolyte battery. Concorde soon discontinued the gel product line and concentrated all engineering developments on the AGM product line. In 1987, Concorde began supplying the photovoltaic (PV) industry with our deep cycle AGM batteries. Over the years it has been our design expertise, quality and customer focus that has made Concorde a leader in providing the best battery available for the PV and Renewable Energy markets. Concorde is committed to the proposition that the customer deserves the best performing and highest quality product. Our batteries are tailored to the application rather than make the designer/user settle for what is available. It is this commitment – to meet the needs of the customer – that sets Concorde apart.

1.2 Overview of Sun Xtender® AGM Technology

Sun Xtender® AGM batteries are valve-regulated, recombinant gas, absorbed electrolyte, lead acid batteries. The cells are sealed with a pressure relief valve that prevents gases within the battery from escaping. The positive and negative plates are sandwiched between layers of glass mat consisting of a blend of glass micro fibers of varying length and diameter. This blend features superior wicking characteristics and promotes maximum retention of the electrolyte. An envelope of micro porous polyethylene surrounds each wrap of glass mat to further protect the plates from shorting. Electrolyte is absorbed and held in place by the capillary action between the fluid and the glass mat fibers. The mat is over 90% saturated with the electrolyte. By design it is not totally saturated with electrolyte, a portion is filled with gas. This void space provides the channels by which oxygen travels from the positive to the negative plates during charging. When the oxygen gas reaches the negative plate, it reacts with lead to form lead oxide and water. This reaction at the negative plate suppresses the generation of hydrogen that otherwise would come off the negative plate. In this manner, virtually all of the gas is "recombined" inside the cell, eliminating the need to add water, resulting in "maintenance free" operation. Furthermore, since the acid electrolyte is fully absorbed in the AGM separator, the battery is nonspillable even when turned upside down.

1.3 About this Manual

This manual is intended to provide the customer with technical information for selecting, installing, operating, and servicing Sun Xtender® AGM batteries. The next Chapter provides a detailed description of the product, its design features and materials of construction. Concorde is very proud of this innovative product line and we think you will share our enthusiasm. Chapter 3 provides a comparison of Sun Xtender® with other lead acid technologies: flooded-electrolyte batteries, gelled-electrolyte batteries, and AGM batteries from other manufacturers. Chapter 4 presents an overview of the battery specifications for the Sun Xtender® product line; detailed specifications for each model are published separately. Chapter 5 provides instructions for storing, operating and servicing Sun Xtender® AGM batteries. Chapter 6 gives an application guide and Chapter 7 gives important safety information. Further technical information can be found in the Appendices. If you have additional questions beyond what is covered in this manual, please contact Concorde Battery Corporation or any of our distributors.

CHAPTER 2 - BATTERY CONSTRUCTION

2.1 Component Description

Refer to the battery pictorial in Section 2.2 showing a cut away view of the cell and a summary of the features and benefits. A more detailed description of the battery's construction is given below.

GRIDS - The negative grid is made of pure lead calcium alloy. The positive grid is extra thick and is made from a proprietary, pure lead-tin-calcium alloy with special grain refiners. These features improve corrosion resistance of the grid and gives the battery excellent cycling capability and float life.

PLATES – The grids are pasted on state-of-the-art pasting machines to give the highest quality plates with tightly controlled weight and thickness specifications. The lead oxide paste used to make the positive plates is our high density formula. With time and use, the active material tends to soften and give less discharge capacity. The high density paste formula retards the active material softening and extends battery life.

ABSORBENT GLASS MAT [AGM] SEPARATOR – The AGM is a premium blend of glass micro fibers having an optimum ratio of fine and extra fine fiber sizes. This blend features superior wicking characteristics and promotes maximum retention of the electrolyte. The AGM layer is squeezed to an optimum level of compression during assembly to provide sufficient contact with the surface of the plate over the life of the battery. This compression also promotes retention of the active material if the battery is exposed to shock or vibration conditions.

POLYETHYLENE ENVELOPE – Concorde is only manufacturer that envelopes the AGM separator with a thin layer of microporous polyethylene. The microporous layer is wrapped around the glass-matted plate and then sealed along the sides to eliminate the possibility of shorts at the edges of the plate (a common failure mode). The microporous polyethylene is more durable and puncture resistant than the AGM material alone and significantly reduces the occurrence of plate to plate shorts.

INTERCELL CONNECTIONS - Massive "over the partition" fusion welds are used which increase the strength of the intercell connection. This minimizes the possibility of open welds and provides a low resistance connection between cells. Other manufacturers use "through the partition" spot welded construction that inserts a weak point into the assembly because of the small cross section area and the difficulty of making a reliable weld and leak proof construction.

HIGH IMPACT, REINFORCED CONTAINER & COVER – The battery container and cover are made of a thick walled polypropylene copolymer. This material provides excellent impact resistance at extreme low temperatures and minimizes bulging at high temperatures.

COVER-TO-CONTAINER SEAL - The batteries use an epoxied tongue and groove seal between the cover and container. Most other manufacturers heat seal their cover to the container. The epoxied tongue and groove is a far stronger seal and will not separate in high or low temperature extreme applications.

PRESSURE RELIEF SAFETY VALVE - Each cell in the battery employs a pressure relief safety valve. The valve is designed to release excess pressure that builds up over time to vent the small quantity of gasses that do not recombine inside of the battery. Once the pressure is released, the valve automatically re-seals. The gasses that escape are mainly oxygen and some hydrogen, and these gasses rapidly dissipate into the atmosphere.

TERMINALS - Sun Xtender® AGM batteries employ copper alloy (i.e., silicon bronze) terminals providing an improved low resistance electrical connection. The copper alloy terminals are non corrosive. Additionally, the copper alloy terminals offer increased environmental protection and personal safety in comparison to commonly used lead terminals. The terminals on most Sun Xtender® AGM batteries are recessed below the top of the battery cover. This prevents short circuiting across the battery terminals. Refer to the pictorial in Section 2.3 to see a detailed view of the various terminal designs that are available.

HANDLES – Lifting handles are incorporated into most Sun Xtender® AGM batteries. This provides easier handling for lifting, carrying and installation.

2.2 Battery with Cut Away View

SUN XTENDER® SERIES
...the heart of your solar system

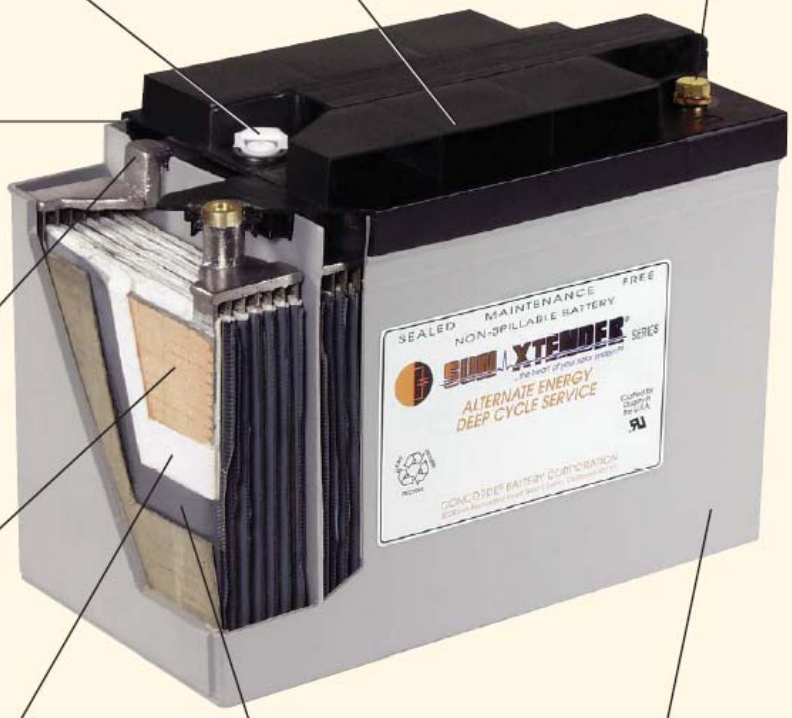
Valve Regulated - Absorbent Glass Mat (VR-AGM) Sealed Lead Acid Batteries

Sealed, Pressure Relief Safety Valves
Operates in any orientation without leaking. Maintenance-free; never requires water additions

Lifting Handles
Easier handling, carrying & installation

Copper Alloy Terminals
Provides low resistance electrical connection (copper-to-copper), non-corrosive. Increased environmental protection & personal safety - no exposed lead

Cover-To-Container Seal
Strong, epoxied tongue & groove cover/container seal will not separate even under extreme temperature & pressure changes or vibration



Intercell Connections
Massive "over-the-partition" weld increases the weld strength & provides low resistance connection path

Thick Plates And High Density Oxide Paste Materials
Insures long life, excellent cycling capability

Absorbent Glass Mat (AGM) Separator
Custom designed and manufactured to provide superior wicking characteristics for electrolyte retention

Polyethylene Envelope
Eliminates internal shorts caused by shock, vibration & dendrite growth

Reinforced Copolymer Polypropylene Container & Cover
High impact resistance and resists bulging even under severe overcharge and temperature

...The heart of your system®
CONCORDE

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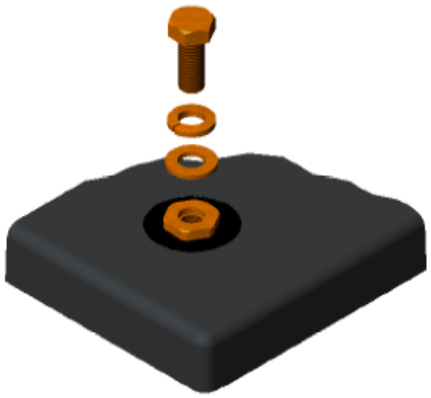
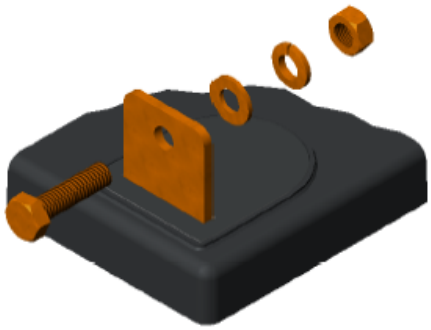
2.3 Terminal Types

Sun Xtender Battery Terminal Types

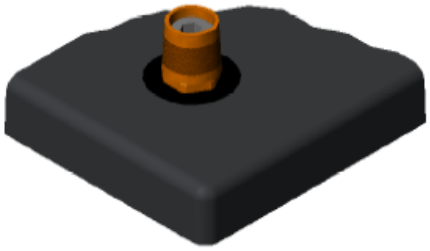
Copper Alloy Corrosion Free Connections for Maximum Conductivity



M8 Threaded Insert (Copper Alloy)
M6 Threaded Insert for PVX-340T & PVX-420T only



L-Blade Terminal (Solid Copper)
M8 Hardware



"A" - SAE Automotive Post (Copper Alloy)
Available as a separate kit, or installed at the factory
Kit Part Number: 6918

CHAPTER 3 - TECHNOLOGY COMPARISON

3.1 Sun Xtender® versus Flooded Batteries

Flooded-electrolyte lead acid batteries have been around since 1859 and tend to be less expensive than AGM or Gel batteries. However, they have major deficiencies compared to AGM or Gel batteries. For instance, deep cycle flooded lead acid batteries contain antimony in the grid alloy which causes a high rate of self discharge and rapid water loss due to gassing reactions. The escape of hydrogen and oxygen from the battery represents a serious safety hazard if the gasses are not ventilated properly. In flooded batteries, replacing the antimony lead alloy with calcium lead alloy reduces the amount of gassing and water loss, but the cycle life is much lower and they are no longer considered deep cycle batteries.

Electrolyte stratification can occur in all types of flooded batteries. As the battery is discharged and charged, the concentration of acid becomes higher at the bottom of the cell and becomes lower at the top of the cell. The low acid concentration reduces capacity at the top of the plates, and the high acid concentration accelerates corrosion at the bottom of the plates and shortens the battery life. Although stratification can be minimized by raising the charging voltage so that the increased gassing agitates the electrolyte, this will accelerate the water loss and watering frequency.

One other difference is that flooded batteries can not tolerate freezing temperatures when in the discharged state, whereas AGM batteries are not damaged by freezing temperatures. The following table provides a side by side comparison of Sun Xtender® AGM and flooded deep cycle batteries.

Characteristic	Sun Xtender® AGM Battery	Flooded Deep Cycle Battery
Self Discharge	1 to 3% per month – remains stable over life.	5-10% per month when new – increases drastically with age due to antimony contamination of the negative plate.
Water Addition	Never.	Frequent – increases dramatically with age due to antimony contamination of the negative plate.
Hydrogen Gas Emissions	Negligible unless severely overcharged.	Significant volume is generated and must be ventilated to prevent explosion.
Electrolyte Spillage	Non-spillable in all orientations – electrolyte is retained in AGM separator.	Spills when tilted, inverted, or cracked.
Electrolyte Stratification	No stratification occurs.	Stratification occurs when operated at low charging voltages or in taller batteries.
Tolerance to freezing temperatures	No damage when frozen.	Battery destroyed when frozen.

3.2 Sun Xtender® versus Gel Batteries

Gel batteries have been commercially available since the early 1970's and are still offered by some manufacturers. Concorde manufactured gel batteries for many years before developing the AGM technology and, therefore, is aware of inherent deficiencies associated with gel batteries.

The gel product employs a highly viscous, semisolid mixture of silica gel and dilute sulfuric acid in a colloidal suspension as an electrolyte. The electrolyte is difficult to keep homogeneous and the solid silica can separate from the acid, creating a "flooded" battery. Handling and vibration exposure are operational factors that can cause the silica and acid mixture to separate as there is no chemical bond. In high temperature environments, the semisolid electrolyte develops cracks and voids that reduce contact between the plates and causes the battery to lose capacity. This same effect gradually occurs even at normal room temperatures.

By contrast, AGM batteries employ a glass micro fiber mat separator that holds the liquid electrolyte like a sponge. Shrinkage of the separator does not occur as the battery ages and the electrolyte remains in direct contact with the plates. The electrolyte remains immobilized even when the battery is exposed to severe vibration, so electrolyte spillage or leakage is prevented.

Since it is easier to fill a container with a liquid than a semi-solid, AGM batteries require less space between battery plates. The closer plate spacing gives the AGM battery a lower internal resistance, making it more charge efficient and giving better power performance on discharge, especially at low temperatures.

Gel batteries are also more sensitive to charging voltage. If the charging voltage is not controlled within a very tight range relative to the battery's temperature, the life of the battery will be adversely affected. For example, one manufacturer of gel batteries claims that if the charging voltage is 0.7V higher than the recommended level, the cycle life will be reduced by 60 percent. The reason for this effect is the limited oxygen recombination capability of gelled batteries. Sun Xtender® AGM batteries are more forgiving in overcharge conditions and their ability to recombine the hydrogen and oxygen gases back into water is more efficient. With Sun Xtender® AGM batteries, tests have shown that increasing the charging voltage 1.0V above the recommended charging voltage results in only a 23% reduction in the cycle life.

The charge acceptance of gel batteries is also less than that of Sun Xtender® AGM batteries. This means it takes longer to recharge gel batteries. As an example, tests have shown that when discharged to 50% of rated capacity (fairly common in a PV system), gel batteries took twice as long to reach full charge as compared to Sun Xtender® AGM batteries.

The following table provides a side by side comparison of Sun Xtender® AGM and gel batteries:

Characteristic	Sun Xtender® AGM Battery	Gel Batteries
Electrolyte Stability	Excellent – AGM acts like a flexible sponge.	Prone to solid / liquid separation leading to spillage / spewage of acid and premature failure. Electrolyte loses contact with plates due to cracks and voids as the battery ages, especially at higher ambient temperatures.
High Rate Performance	Excellent due to low internal impedance.	Inferior. Plate spacing must be greater to allow for gel passage during filling. Gel adds to impedance, especially at low temperatures.
Sensitivity to Charging Voltage Levels	Moderately sensitive. Life is somewhat reduced if charged outside of recommended charge voltage levels.	Very Sensitive. Life is greatly reduced if charged outside of recommended charge voltage levels.
Charge Acceptance Rate	Excellent. Battery can be fully charged in 2 hours if high inrush current is available.	Inferior. Must limit in rush current and charge time is at least twice as long to reach full charge.

3.3 Sun Xtender® versus other AGM Batteries

Sun Xtender® AGM batteries have been specifically designed for true deep cycle, long service life capability in adverse temperature and handling conditions. Concorde uses extra thick positive plates, high density paste, thick AGM separator layers encased within a microporous polyethylene envelope, thick walled containers with epoxy-sealed covers. A side by side comparison of Sun Xtender® AGM batteries with typical AGM batteries from other manufacturers is provided in the following table:

Characteristic	Sun Xtender® AGM Battery	Other AGM Batteries
Positive Grids	Extra thick grids (typically 0.095" or greater) and extra thick plates (typically 0.105" or greater), for long cycle and float life.	Thinner grids, typically 0.045 to 0.060".
Pasted Plates	High density positive paste for long cycle life.	Lower density, resulting in lower cycle life.
AGM Separator	Extra thick for maximum electrolyte reserve. Premium grade of AGM with extra fine fibers for long life.	Thinner material used. Inferior grade of AGM without the extra fine fiber content.
Microporous polyethylene separators	Envelopes the positive plate to prevent shorting due to shock, vibration and dendrites	Not present, AGM is the only separator protecting the plates.
Intercell connections	Massive over the partition connectors provide a robust, leak proof connection with low voltage loss.	Inferior through the partition welds have less cross sectional area, provide weaker structural connection, and are leak prone.
Battery Terminals	Copper alloy – low electrical resistance and no exposed lead.	Lead alloy - higher in electrical resistance and user is exposed to lead contamination.
Container	Thick wall for rigid support of cell elements and high compression of AGM separator.	Thinner walls, less support of cell elements and lower compression of AGM separator.
Cover Seal	Cover is epoxied to container – high strength bond for reliable operation at temperature extremes.	Cover is heat sealed (melted) to container – prone to separation and leakage at temperature extremes.

CHAPTER 4 - BATTERY SPECIFICATIONS

4.1 Battery Models

The Sun Xtender® Series consists of batteries ranging in capacity from 34 to 915 ampere hours (rated at the 24 hour rate). A variety of 2-volt, 6-volt and 12-volt models are available. Refer to the battery specification sheet (published separately) for a complete listing of the mechanical and electrical specifications for each battery model.

4.2 Terminals

Standard Terminals**:** Batteries with a "T" at the end of the part number incorporate M6 or M8 (copper alloy) threaded insert terminals. Batteries with an "L" at the end of the part number incorporate "L" Blade (solid copper) terminals. All batteries are supplied with silicon bronze bolts, nuts, and washers required for installation.

Optional (Copper Alloy) Terminal Installed at the Factory: Batteries with a "T" at the end of the part number (except PVX-340T & PVX-420T) are available with an optional factory installed SAE automotive type terminal by adding the "A" suffix to the end of the part number. For example, order PVX-1040TA instead of PVX-1040T.

Optional (Copper Alloy) Terminal Kit: Kits can be ordered for "After Factory" customer conversions of "T" type batteries (except PVX-340T & PVX-420T) by ordering P/N 6918 for the "A" SAE automotive post kit. Kit includes terminals and installation bolts required for installation.

Terminal Torque Values**:** M6 use 35 in-lbs / 4.0 nm. M8 use 70 in-lbs / 7.9 nm.

4.3 Handles

All batteries include built in lifting handles except the PVX-490T and PVX-560T.

4.4 Definition of Ratings

Capacity ratings are after 15 cycles per BCI specifications and are stated at 77°F (25°C) to 1.75 volts per cell.

4.5 Temperature Range

Storage: -55°C (-67°F) to 50°C (122°F). Operating: -40°C (-40°F) to 71°C (160°F).

4.6 UL Recognition

All Sun Xtender® AGM batteries meet the requirements of UL® 1989 (Standby Battery) and are UL recognized under UL File Number MH-17983.

4.7 Shipping Classification

Sun Xtender® AGM batteries have been tested and determined to be in compliance with the vibration and pressure differential tests in accordance with DOT 49 CFR 173.159(d) and Special Provision A67 of the International Air Transport Association (IATA) Dangerous Goods regulations. As such, they are classified as a "NONSPILLABLE BATTERY" and can be shipped as non-hazardous material by any means. To comply with DOT shipping regulations, the battery must be packaged to protect against short circuits and the battery and outer packaging must be plainly and durably marked "NONSPILLABLE" or "NONSPILLABLE BATTERY".

CHAPTER 5 - COMMISSIONING AND SERVICING INSTRUCTIONS

5.1 Storage

Sun Xtender® Batteries are charged at the factory and are ready for installation when they are received. Batteries may be stored prior to installation for up to 2 years, provided they are boost charged as described below. Batteries should be stored in the coolest environment available, preferably not exceeding 20°C (68°F). The higher the temperature, the faster the battery will self-discharge and require boost charging. See Appendix C for data on storage time versus temperature.

While in storage, batteries should be boost charged every 90 days or when the open circuit voltage (OCV) drops to 2.08 volts per cell (12.5 volts for a 12 volt battery). This OCV corresponds to approximately 75% state of charge. Boost charge batteries using a constant voltage charger set at 2.45 volts per cell (14.7 volts for a 12 volt battery) at a temperature of 20°C (68°F). If the temperature is above 20°C (68°F), compensate the charge voltage by subtracting 0.04V/cell for every 10°C difference (0.24V for a 12 volt battery). If the temperature is below 20°C (68°F), compensate the charge voltage by adding 0.04V/cell for every 10°C difference. The boost charge should be applied until the charging current falls below 0.5 percent of the battery's 24 hour rated capacity (0.5 amps for a 100 Ah battery). The time it takes for boost charging can be estimated from the following equation, based on the battery state of charge (SOC), rated capacity, and rated output of the charger:

Time to Reach Full Charge = [(1-SOC/100) x Rated Capacity (Ah) ÷ Rated Output of Charger (Amp)] + 2 hours.

For example, when boosting a 258 Ah battery at 75% SOC using a 15A charger, the charging time can be estimated as follows:

Time to Reach Full Charge = [(1-75/100) x 258 Ah ÷ 15A]+ 2 hours = 6.3 hours.

5.2 Installation

Be sure there is adequate ventilation in the area where the batteries are to be installed (see Chapter 7). Batteries may be installed in any orientation except upside down (i.e., terminals facing the earth). The space surrounding adjacent batteries should be at least 0.25 inch to permit airflow around each battery. Always use batteries of the same size and condition in multi-battery installations. When replacing batteries, it is best to replace the entire set of batteries so they remain balanced.

Connect batteries using cabling that is sized for the maximum load of the system. The voltage drop on the cables during charging should not exceed 0.2 volts at full output. Protect the battery terminals from shorting during installation.

Batteries may be connected in series (voltage adds, capacity stays the same), in parallel (capacity adds, voltage stays the same), or a combination of series and parallel (voltage and capacity adds). Each of these connection options are illustrated in Figures 5-1 through 5-3, respectively.

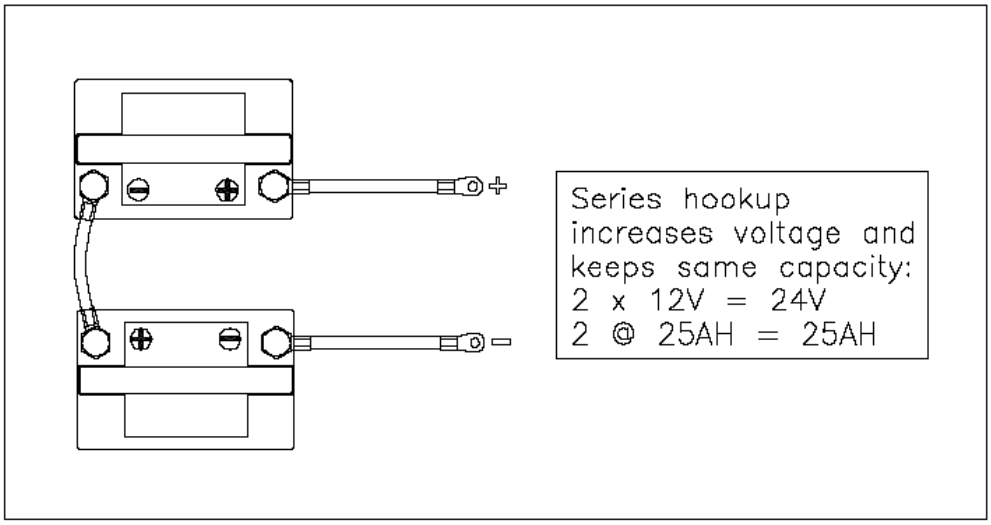


Figure 5-1. Series Connection

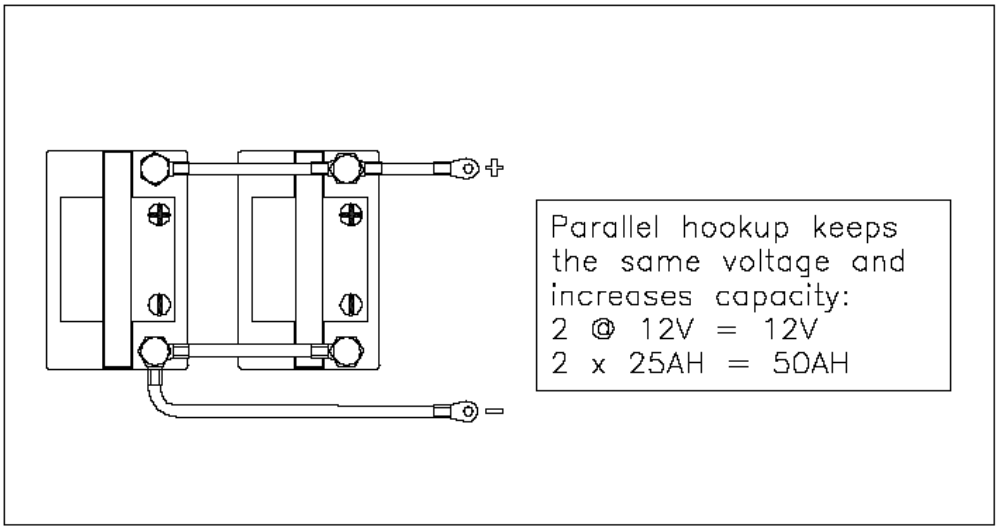


Figure 5-2. Parallel Connection

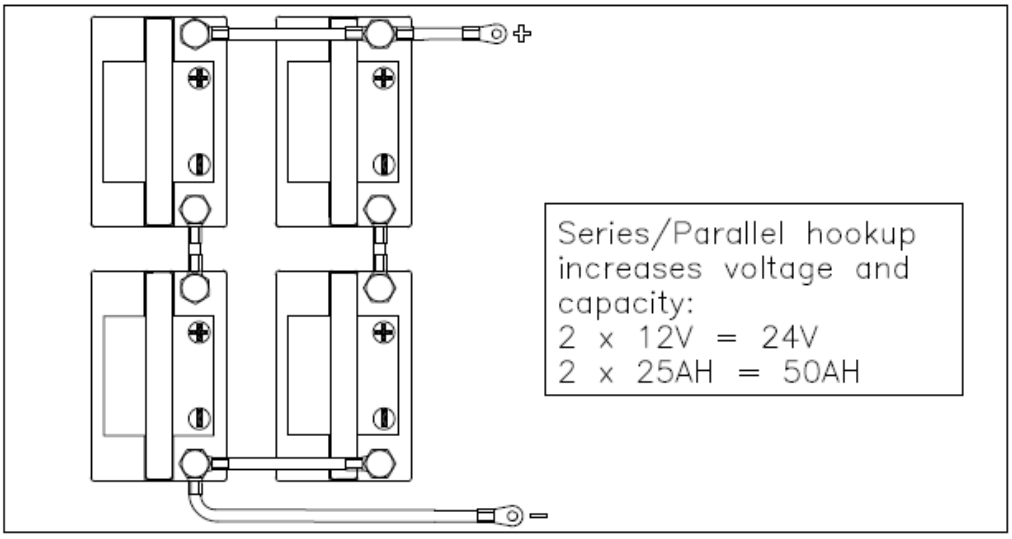


Figure 5-3. Series/Parallel Connection

Connection options for 4-terminal batteries are illustrated in Figures 5-4 through 5-9. For low rate applications (current levels less than 400 amperes), only two of the four terminals need to be connected, but it is still best to use all four terminals for redundancy. For high rate applications (current levels greater than 400 amperes), all four terminals should be connected.

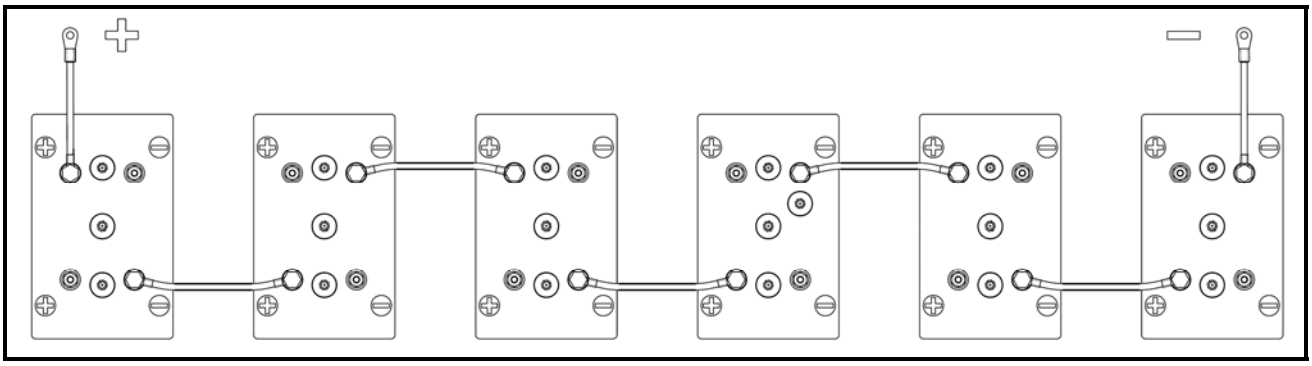


Figure 5-5. Series Connection for 4-Terminal Batteries (Low Rate Applications Only)

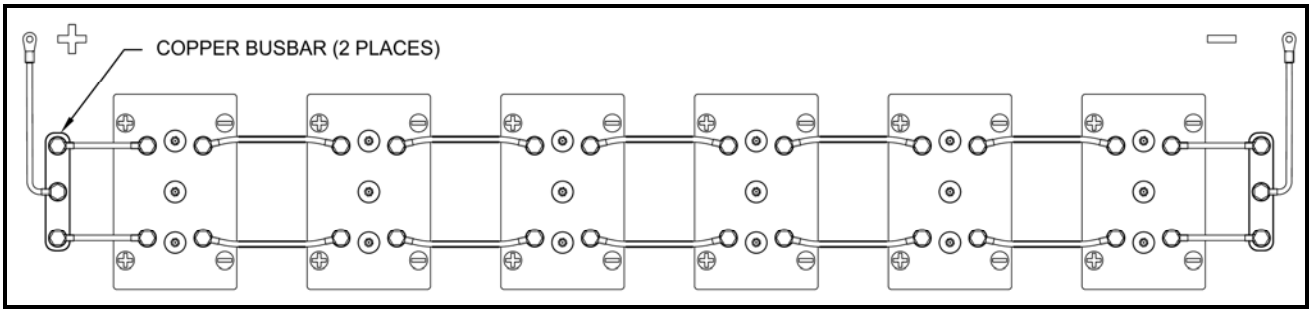


Figure 5-6. Series Connection for 4-Terminal Batteries (Low or High Rate Applications, Option A)

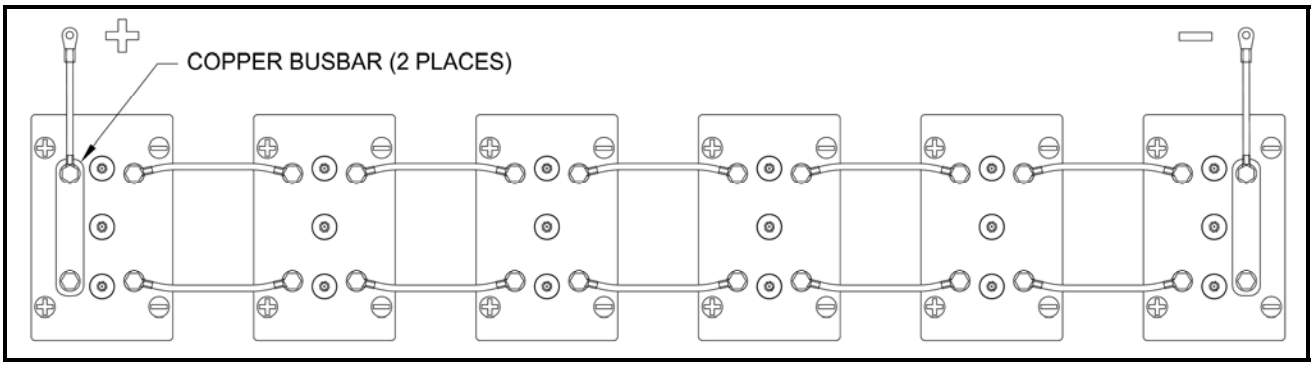


Figure 5-7. Series Connection for 4-Terminal Batteries (Low or High Rate Applications, Option B)

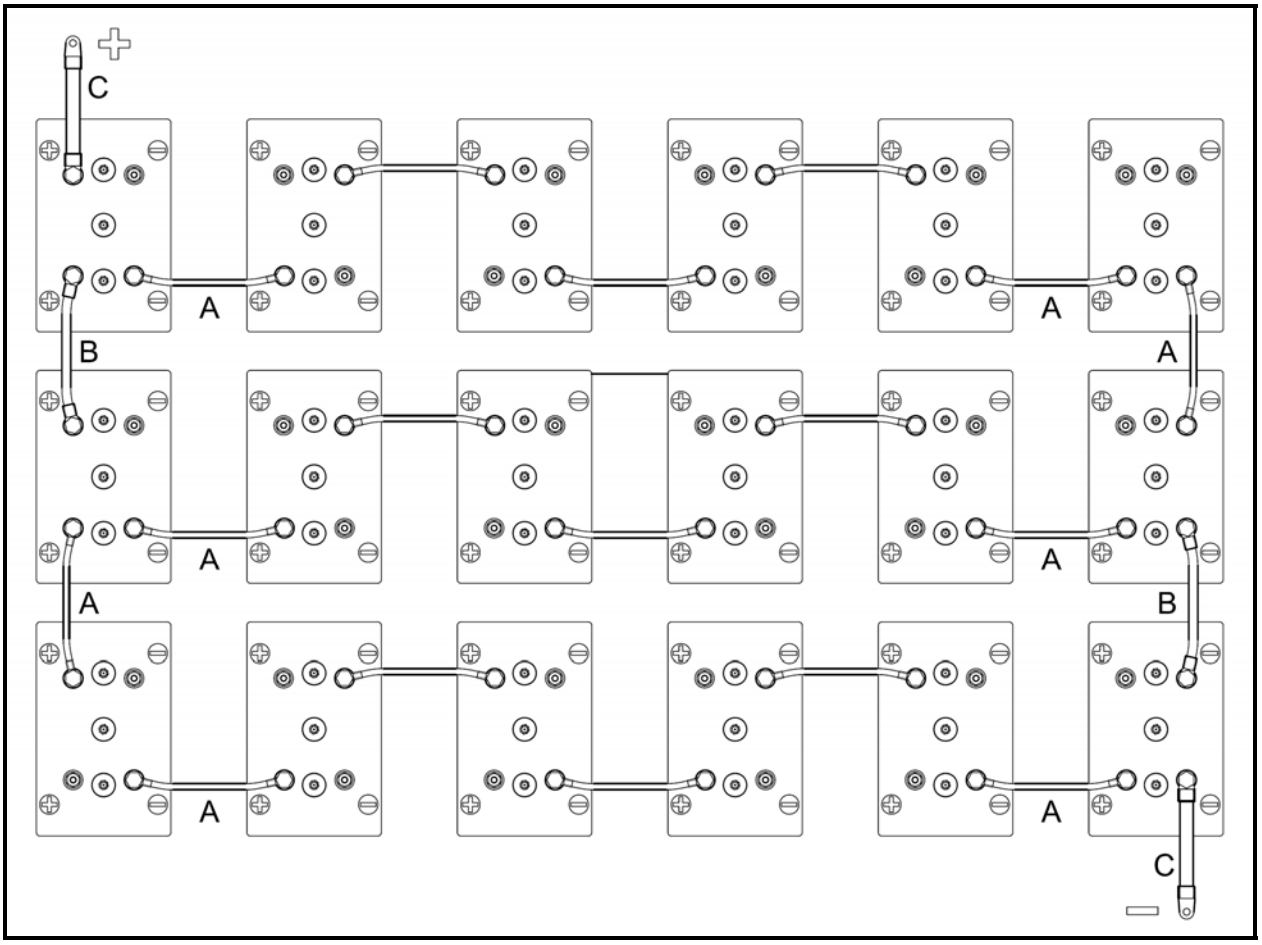


Figure 5-8. Series/Parallel Connection for 4-Terminal Batteries (Low Rate Applications Only)

NOTE: Cables A, B and C carry different current levels and should be sized accordingly. In this example, the current in Cable B is 2 times that of Cable A and the current in Cable C is three times that of Cable A.

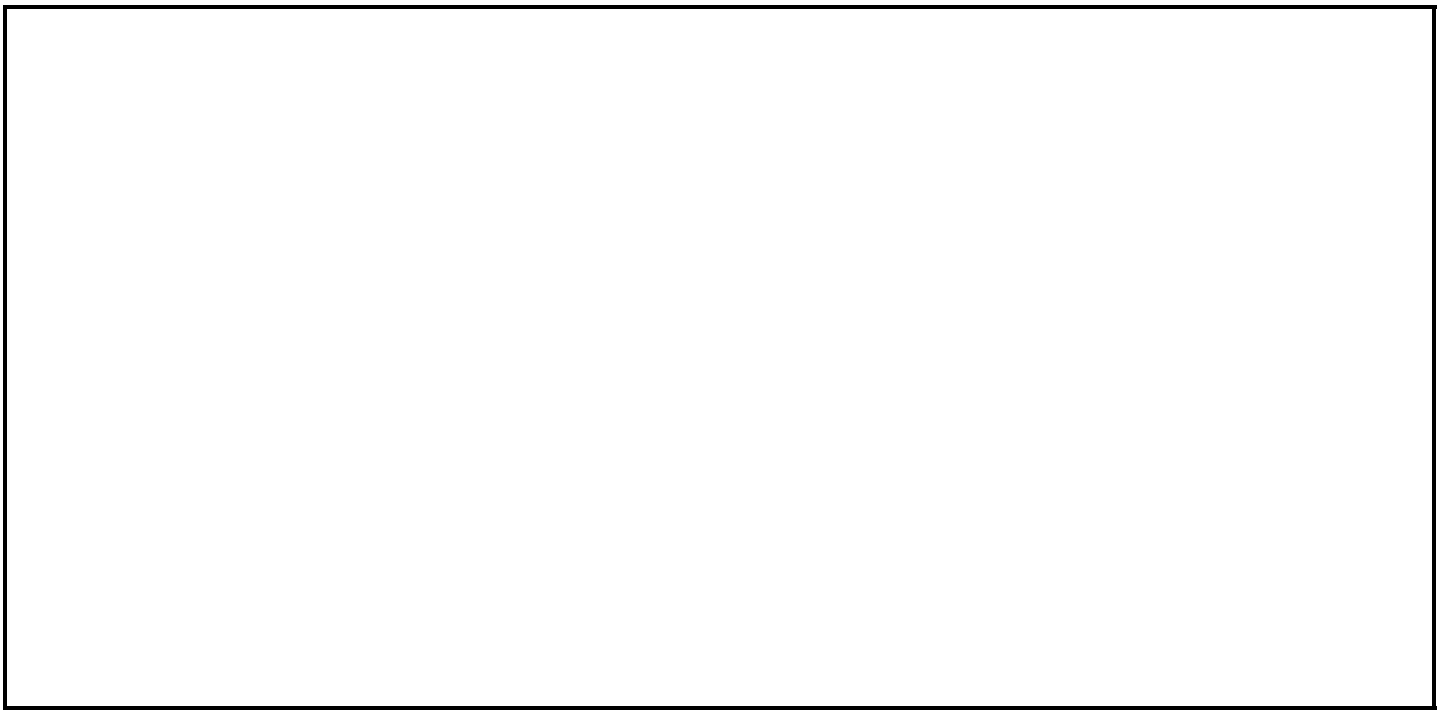


Figure 5-9. Series/Parallel Connection for 4-Terminal Batteries (Low or High Rate Applications)

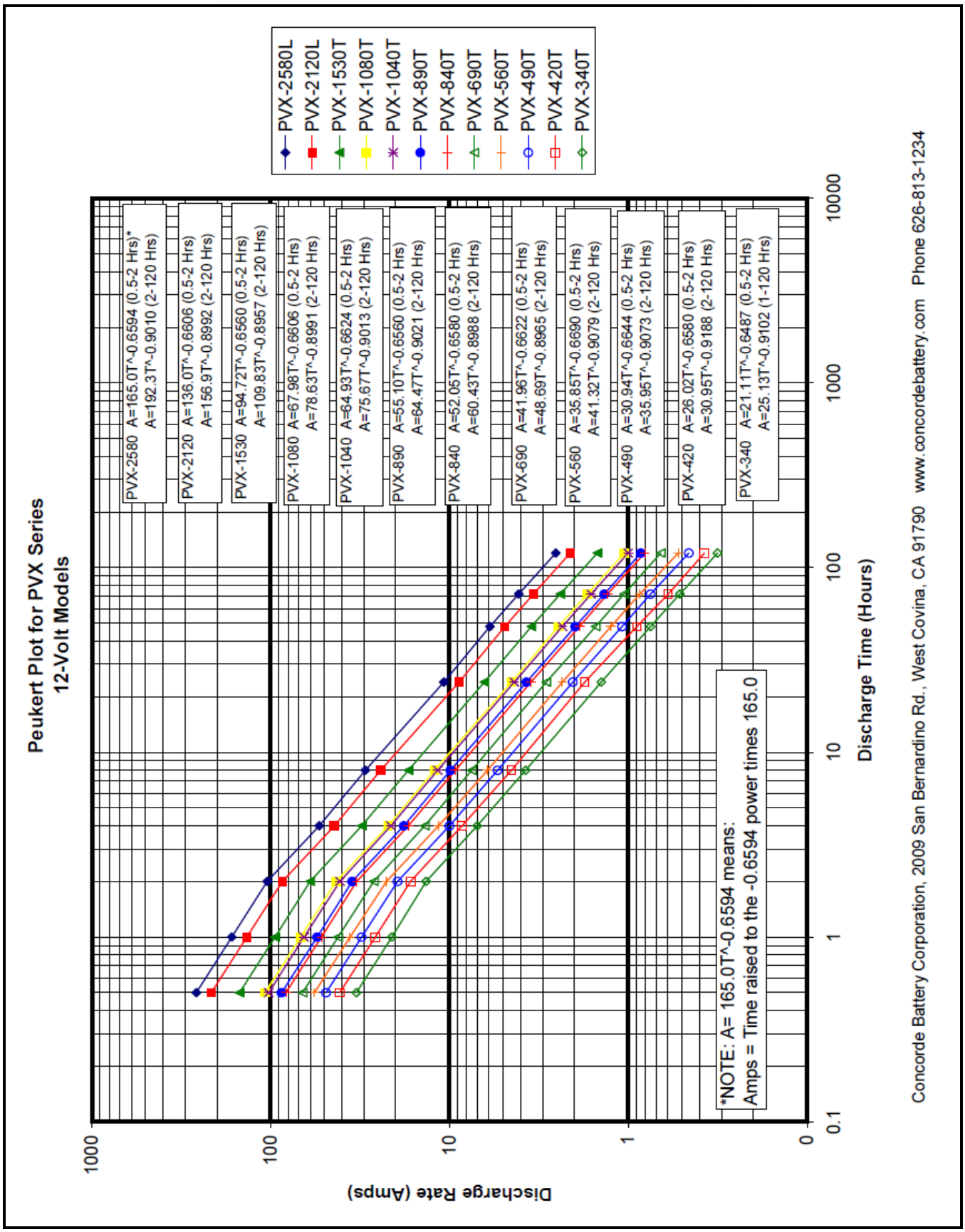
5.3 Discharging

Discharge data for Sun Xtender® AGM batteries are given in Appendix C. The capacity delivered by the battery depends on the rate of discharge as well as the battery temperature. The battery will deliver less capacity as the discharge rate increases and less capacity as the temperature is lowered. Graphs are provided in Appendix C to quantify these effects. Peukert plots (Amps vs Time) are also included, along with formulas for calculating the current that can be removed for any discharge time from 0.5 hours to 120 hours. To calculate the discharge time for a specified amperage, these formulas can be inverted as follows:

$A = C \times T^{-n}$
$T = C^{1/n} \times A^{-1/n}$

(where A = Amps, T = Time in hours, C & n are constants specific for each battery model).

In general, batteries should be sized such that the rated capacity is at least twice the capacity required by the load. For example, if 100 Ah is required on average, select at least a 200Ah battery. This approach will limit the average depth of discharge to 50% and will dramatically extend the life of the battery (see chart of Cycle Life versus Depth of Discharge in Appendix C).



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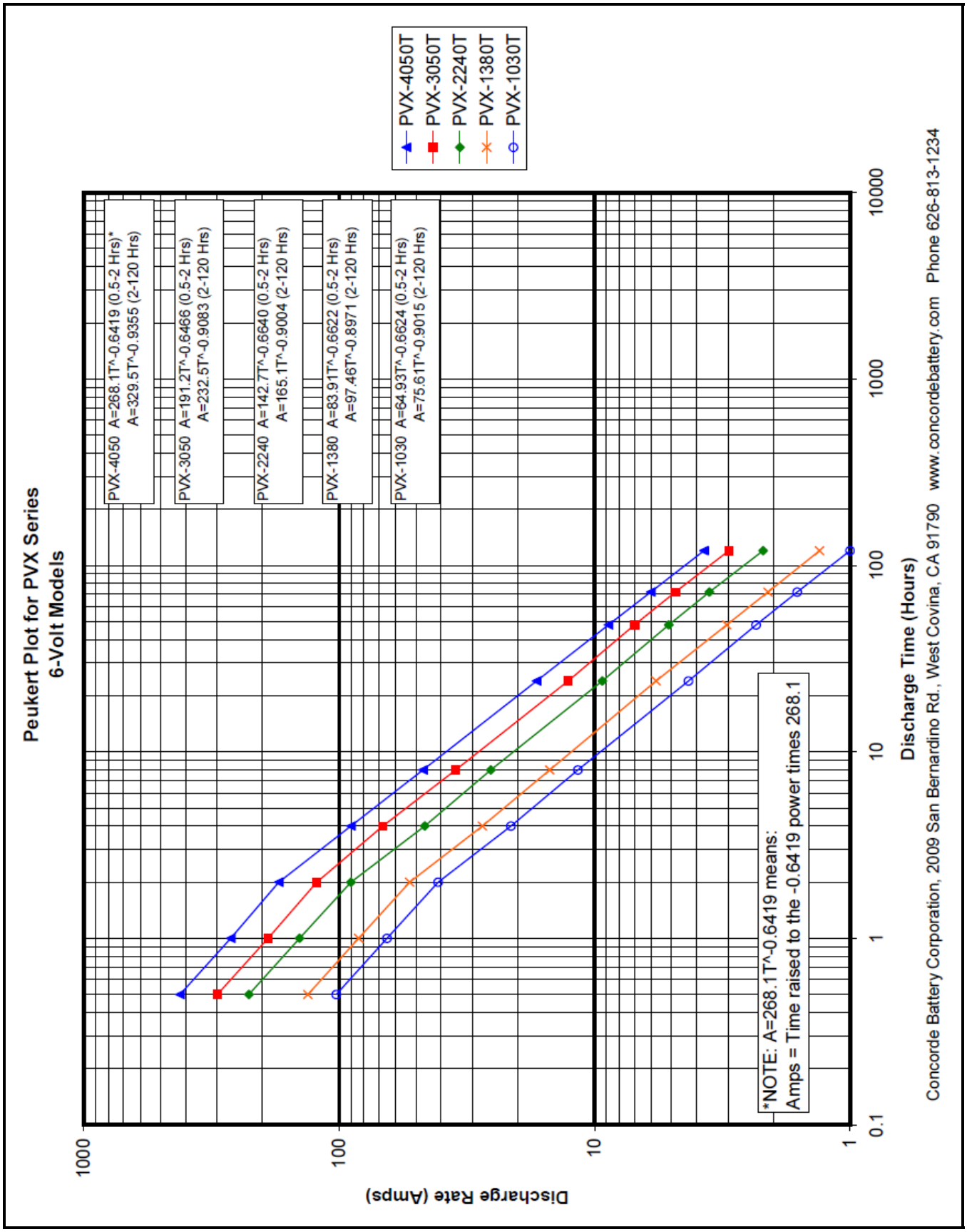

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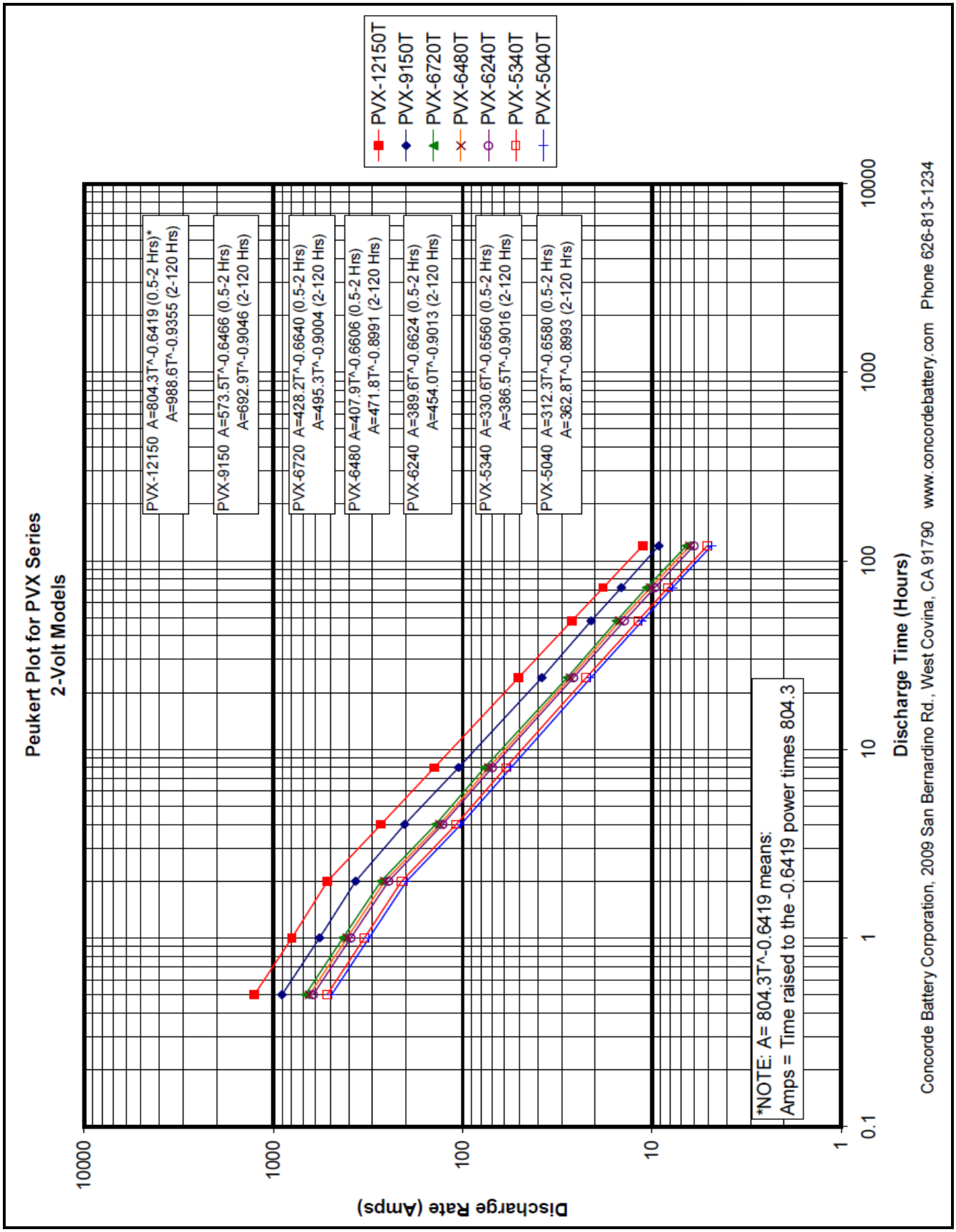

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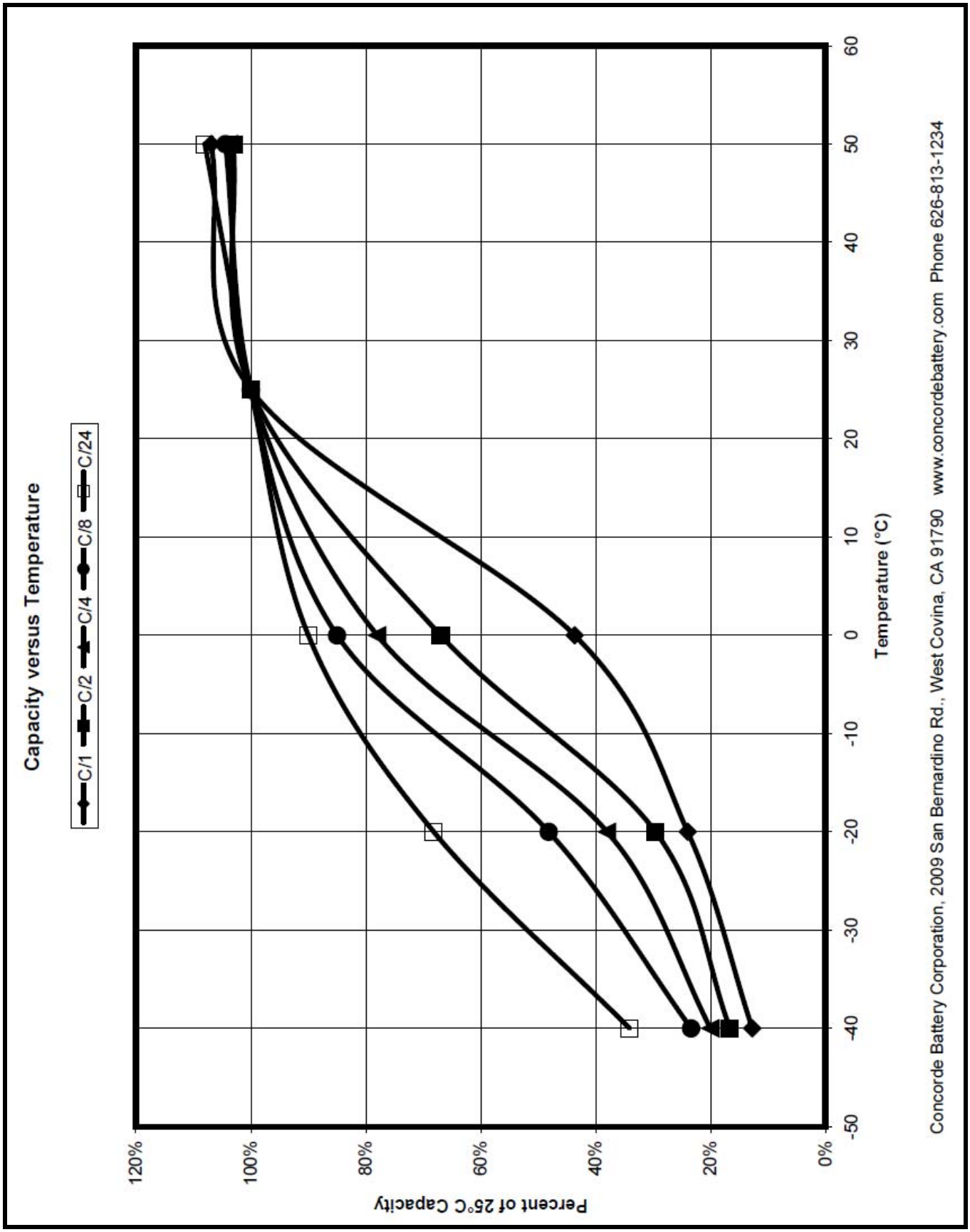

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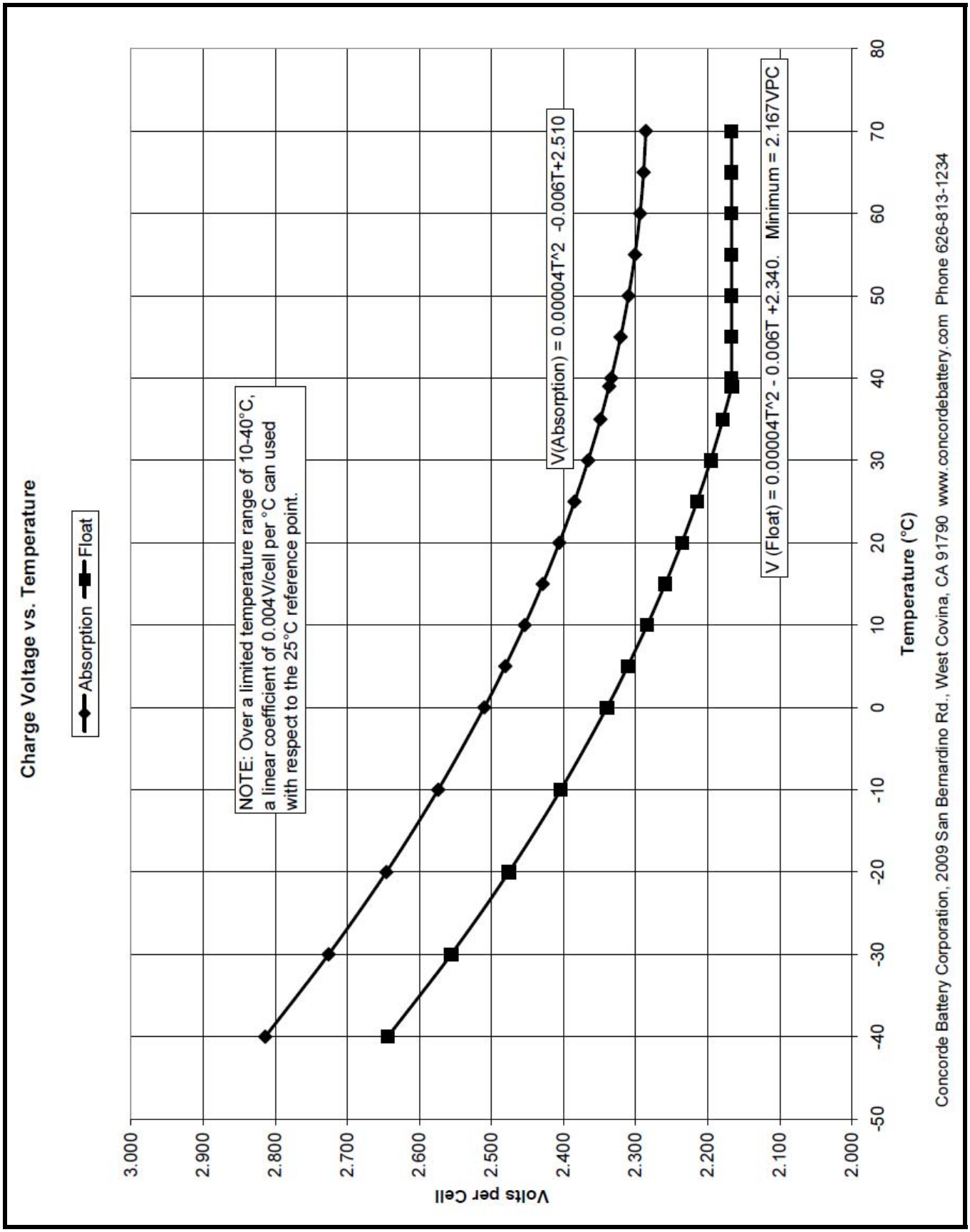

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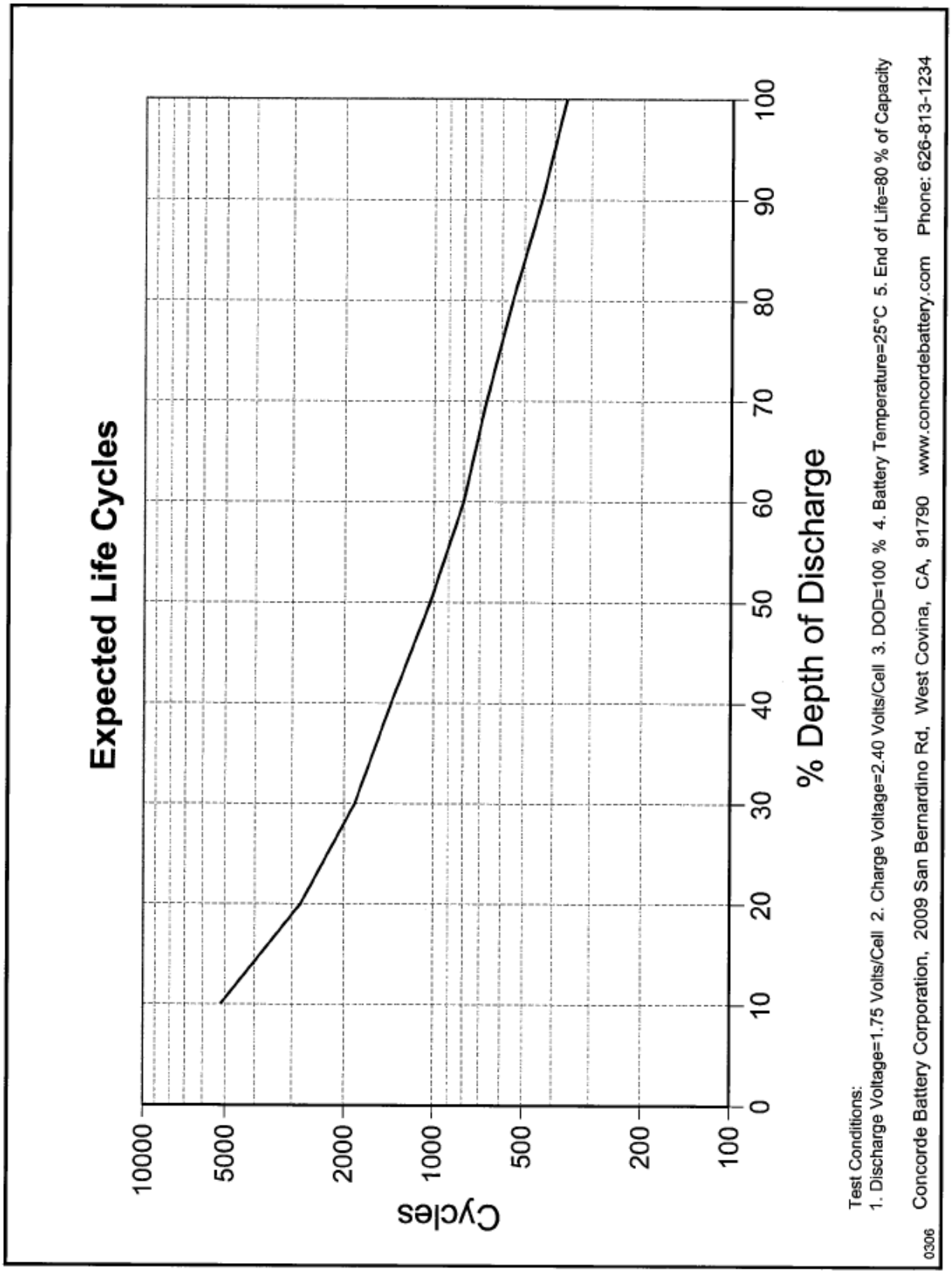

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