

**B**attery  
Application  
Handbook

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*For Cyclon<sup>®</sup> and Genesis<sup>®</sup>  
Sealed-Lead Products*

*Second Edition*

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**F**or more product-specific technical information on your application, please consult your local Hawker Energy Products Inc. representative, or call our customer service department. Application help is also available from the technical support department.

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## INTRODUCTION

**T**

his brief guide covers both the Cyclon<sup>®</sup> and Genesis<sup>®</sup> rechargeable sealed-lead battery product lines and is intended to serve as an introduction to various aspects of pure lead-tin battery applications.

It is hoped that these notes will be useful to those looking for general information on the proper use of these two power sources, manufactured exclusively by Hawker Energy Products Inc., in Warrensburg, Missouri, USA.

**F**

ollowing is a list of key features applicable to both Cyclon® and Genesis® batteries:

▼ **Maintenance-free design**—Cyclon and Genesis cell designs incorporate sealed, starved electrolyte chemistry with permanent, hardened termination on all product models.

▼ **Orientation flexibility**—These batteries may be installed and operated in any orientation, allowing greater flexibility in product design and use.

▼ **Negligible gassing**—Gassing under normal charging conditions is negligible, making Cyclon and Genesis safe for installation in human environments, such as offices and hospitals.

▼ **Safety**—Both product lines are Underwriters Laboratory (UL) recognized, as a component per UL Standard 924.

▼ **Wide operating temperature**—Both Genesis and Cyclon offer very broad operating temperature ranges, from -65°C to +65°C for Cyclon, and from -40°C to +60°C for Genesis. (Please refer to product specification sheets for the capability of each product type.)

▼ **Long Life**—Pure lead-tin grid, better than 99.9% recharge recombination efficiency, higher vent design pressures, superior plate-to-cell/cell-compression integrity, and stronger case materials all contribute to the longer life, lasting durability, and extreme ruggedness of our batteries, making both Cyclon and Genesis the preferred choice for a variety of high reliability and high performance applications.

▼ **Superior high rate performance**—Due to their very low internal resistance, both Cyclon and Genesis are capa-

ble of extremely high rates of pulse and continuous discharge, making it possible to use a smaller battery package, than if an equivalent conventional lead battery had been used.

▼ ***Superior low temperature performance***—At -40°C, Cyclon® cells are able to deliver 50% of its C/10 room temperature (25°C) capacity, which is significantly higher than the performance of conventional cells. Similarly, at -20°C, Genesis® batteries will deliver 65% of its 15-minute room temperature capacity, again considerably higher than traditional sealed-lead batteries.

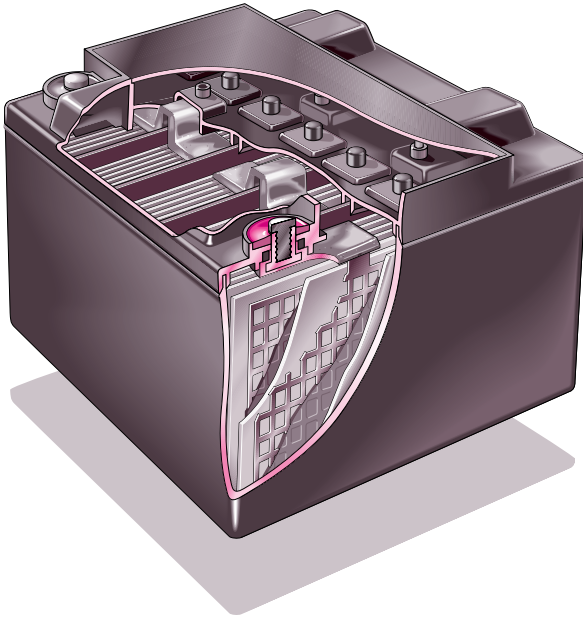
▼ ***Superior fast charging in cyclic applications***—Extremely low internal resistance, coupled with no current limit requirements under constant voltage charging, facilitates very fast recharges in cyclic applications.

▼ ***Flame retardant V0 packaging***—Cyclon single cells and the Genesis SP and EP series are both available in V0 rated case and cover materials. Flash arrestors are standard features in the 120W and 190W Genesis SP series batteries.

On Cyclon single cells, the seal between the V0 rated plastic top and the metal can provides a tortuous path for an external flame attempting to move back into the cell through the resealable vent. This design has proven its merit through 20 years of service history and has been accepted by the telecommunications industry to be functionally equivalent to a flash arrestor.

▼ ***Dry cell classification***—Hawker Energy Products Inc.'s batteries are dry by design and have been tested and determined to be in compliance with section 173.159(d) of the *United States Department of Transportation* (USDOT) regulation. They are excepted from all other shipping requirements of

49 CFR, subchapter 173.159, and as of September 30 1995, all shipments are classified as unregulated “nonspillable wet electric storage batteries.” All batteries and shipping containers are marked “NONSPILLABLE” or “NONSPILLABLE BATTERY.”



THE GENESIS®  
EP AND VP  
MODELS

## APPLICATIONS

**B**oth Cyclon® and Genesis® cells and batteries find homes in a broad range of applications, ranging from standby to highly cyclic. Examples of standby applications are backup power for computers, UPS systems and telecommunications, while typical cyclic applications include electric vehicles, motive, cordless electric lawn mowers and portable instrumentation.

A commonly asked question is what delineates a standby application from a cyclic application? Although there is no clear demarcation between the two types of applications, the answer to this question lies in the response to another question—how much time is available to fully recharge the battery? If at least two weeks (336 hours) are available to accomplish the recharge, then the application is of a standby or emergency nature. It follows then that any recharge time less than 336 hours constitutes a cyclic application.



**T**he key to obtaining maximum life from a sealed-lead battery is optimum charging. Based on the specific characteristics of an application, the recommended charging parameters would vary. While there are several effective methods to recharge a sealed-lead battery the following statement must be satisfied, regardless of the charge regime selected:

*For every ampere-hour discharged from a battery, between 1.05 and 1.10 ampere-hours MUST be returned to ensure a complete & adequate recharge.*

Broadly speaking, a battery may be recharged using either a *constant voltage (CV)* charger, or *constant current (CC)* charger, or a modification of either or both of these. The exact regime chosen generally depends upon the time and economic constraints imposed by the system.

▼ Constant voltage charging, where a single voltage level is applied across the battery terminals, is the most suitable method to recharge a sealed-lead battery. Both Cyclon® and Genesis® cells and batteries are unique in that neither requires a current limit when using a CV charger. Depending on the CV charger's current limit, it is possible to recharge these batteries from a 100% discharged condition to better than 95% state of charge in less than one hour, using only the float charge voltage.

*Constant  
Voltage  
Charging*

At an ambient temperature of 25°C and a purely float application, the recommended charge voltage is *2.27 volts per cell*

(vpc) for Genesis® Cyclon® D (2.5Ah) and X (5Ah) single cells, and D, X, and E (8Ah) monoblocs, may be float charged at 2.27 to 2.35 vpc at 25°C **provided that the AVERAGE time on charge between two successive discharges is thirty (30) days. The MINIMUM time between two such successive discharges must be no less than fourteen (14) days.** If these minimum recharge times are not practical, then the application must be considered to be cyclic, rather than float, and cyclic charge voltages **MUST** be used. The batteries may be left on charge indefinitely at these float voltages, since the batteries themselves will determine the current drawn based on their requirements.

When CV charging is used in cyclic applications, the voltage level is higher because of the reduced time available for the recharge. In this case, the recommended voltage is 2.45 vpc with a minimum current limit of 1C<sup>1</sup>. Such a high voltage should be applied for a minimum of 16 hours and no more than 24 to 48 hours:<sup>2</sup> After that time, the charger should either be shut off or the voltage lowered to the appropriate float value.

*Constant  
Current  
Charging*

▼ While CC charging for sealed-lead cells is not as popular as CV charging, it is widely used in cyclic applications where a recharge must be accomplished in a relatively short time period.

Although a CC charge enables one to complete a full recharge quicker, greater care must be exercised to prevent any damaging overcharge. The potential for such an overcharge is greater in a CC charge mode, because a high current is imposed on the battery, regardless of its state of charge. This is in contrast to a CV charge regime, in which the battery determines the current it draws.

<sup>1</sup> The C rate is the charge or discharge current in amperes that is numerically equal to the rated capacity of a cell in amperes. For a 5Ah cell, the C rate would be 5A; the C/2 rate would be 2.5A.

<sup>2</sup> These charge times assume a 100% depth of discharge (DOD)

One other point needs to be kept in mind, should one opt for the CC method. Depending on the type and size of the battery, the charge current should be limited to a value ranging from a high of  $C/3$  to a low of  $C/5$  amperes.

▼ There are several other methods, such as two-step CV and two-step CC, to recharge a sealed-lead battery, all of which are variations of the two broad methods outlined above. A fairly widely used method in cyclic applications is a combination CC and CV charge. The regime begins with a CC charge until a certain battery terminal voltage is reached, at which point the charger switches to a CV mode to complete the charge.

Special charge regimes have been developed that enable our batteries to be fully charged, from a 100% DOD in about six (6) hours. (See our EV Handbook for more details on this regime.)

Regardless of the actual method chosen to recharge sealed-lead batteries, one must not lose sight of the fact that ***proper and adequate charging is the single most important factor in obtaining optimum life from a battery, be it float or cyclic.*** If either Cyclon® or Genesis® batteries are to be charged using a multistep charging scheme, **ALWAYS** solicit the advice of Hawker Energy Products Inc.

▼ Heat is a killer of sealed-lead batteries. A rule of thumb is that for every  $7^{\circ}\text{C}$  to  $10^{\circ}\text{C}$  rise in battery ambient temperature above  $25^{\circ}\text{C}$ , the expected life of the battery is reduced by 50%. Thus, a battery rated at 8 years on float at  $25^{\circ}\text{C}$  is only a four (4) year battery at an ambient temperature of  $32^{\circ}\text{C}$  to  $35^{\circ}\text{C}$ . Ideally, then, the battery must be thermally isolated from any source of heat, such as a power transformer.

*Other  
Charging  
Methods*

*Temperature  
Compensation*

This reduction in life is caused by heightened electrochemical activity within the cell as the temperature rises. To partially offset this effect, the charging voltage must be compensated using a negative coefficient. In other words, as the temperature rises, the charge voltage must be lowered. Conversely, as the ambient temperature decreases, the charge voltage must be increased. Note that temperature sensing must be done at the battery itself. Please consult the factory or the specification sheets for the appropriate *temperature compensation* (TC) coefficient.

It is important to understand that while TC is recommended for ambient temperatures significantly above or below 25°C, its implementation does not mean that the effect of a high or low temperature is fully neutralized. Also, rapid fluctuations in ambient temperature do not call for a TC circuit simply because adequate time must be allowed for the battery to reach thermal equilibrium with its environment. In such a case, the charge voltage should be set for an average temperature.

DISCHARGE

**T**he discharge curves at different rates for Cyclon® and Genesis® batteries to specific *end of discharge voltages* (EODV) may be found in the appropriate specification sheets. The capacity in *ampere-hours* (Ah) at any rate may be found by multiplying the discharge rate (measured in amperes) by the time of discharge (measured in hours).

For example, if a battery delivers 2A for 5 hours down to an EODV of 1.70 vpc, then that battery is a 10Ah battery at the 5 hour rate of discharge. All Hawker Energy Products Inc. batteries are rated at the 10 hour rate of discharge.

When considering the overall question of discharge, two factors must be kept in mind—the EODV must be kept high enough to ensure that the battery is not overdischarged for a given application, and the correction factor if the battery is discharged at a temperature significantly higher or lower than 25°C.

Although both Cyclon and Genesis products have excellent overdischarge recovery characteristics, it is recommended that the EODV numbers given in Table I be implemented.

EODV As A  
Function Of  
Rate Of  
Discharge

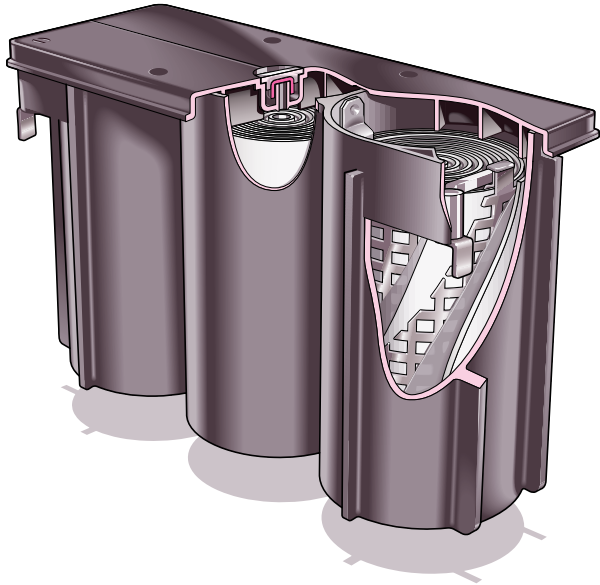
TABLE I

Discharge rate in Amperes	Minimum EODV per cell
0.05C (C/20)	1.75V
0.10C (C/10)	1.70V
0.20C (C/5)	1.67V
0.40C (C/2.5)	1.65V
1.00C	1.60V
2.00C	1.55V
>5.00C	1.50V

Discharge  
Rate  
Correction  
Factor

Since the sealed-lead battery is temperature sensitive, it is good practice to apply a correction factor when the temperature of discharge is other than 25°C. Please consult Hawker Energy Products Inc. for an appropriate correction factor. These factors, suggested by the *Institute of Electrical and Electronic Engineers* (IEEE), are based on both the temperature of discharge, as well as the duration.

THE CYCLON®  
MONOBLOC



**W**hen a battery is kept in storage, i.e. on open circuit, the ambient temperature should be controlled to prolong storage time and maintain maximum capacity over time. To get the best storage results, batteries should be charged prior to storage, stored at room temperature or below, and charged prior to being put back in service.

The OCV of each battery must be monitored on an individual basis. If the OCV measures 1.93 vpc, it has zero effective capacity and should be boost charged immediately. Even if the OCV reads higher than 2.00 vpc at the end of 24 months' storage, the battery should be recharged. Thus, to maintain maximum reliability, batteries should be boost charged once every 24 months, or when the OCV reads 2.00 vpc, whichever occurs earlier.

If the OCV is allowed to drop between 1.93 and 1.80 vpc, some permanent damage may occur to the battery. However, if it drops to less than 1.80 vpc, the battery will most likely be unchargeable by conventional methods. Therefore, under no circumstances must the OCV be allowed to drop below 1.80 vpc.

Just as high temperature accelerates the aging of a battery, so does it accelerate the self-discharge rate of a battery. Thus, when the storage temperature exceeds 25°C, one must monitor the OCV of the batteries more frequently. Conversely, at temperatures less than 25°C, the self-discharge rate reduces, and the time intervals between OCV checks can be correspondingly increased.

## SERVICE LIFE

**T**he service life of a rechargeable battery may be defined either in terms of float life or cycle life. While float life is specified in terms of years it takes to reach end of life<sup>3</sup> at an ambient temperature of 25°C, cycle life is indicated in terms of the number of cycles<sup>4</sup> one can get to a specified *depth of discharge* (DOD).

Float  
(Standby) Life

▼ The float life of a battery is measured in calendar time (years) when essentially all of its life is spent in an over-charge condition. The battery ambient temperature, typically room temperature or 25°C, is also specified. Both Genesis® and Cyclon® cells and batteries have a designed float life of eight (8) years at 25°C.

The float life of a sealed-lead cell is greatly affected by both ambient temperature and charge voltage. As a rule of thumb, every 7°C to 10°C rise in temperature above 25°C reduces the expected float life by 50%. Similarly, every 100mV per cell above the recommended charge voltage also cuts battery float life by 50%. These dramatic numbers highlight the importance of temperature-compensated CV float chargers.

## Cycle Life

The cycle life of a battery is defined as the number of cycles a battery delivers before its capacity falls below the acceptable level, usually defined as 80% of rated capacity. The cycle life of a battery is directly related to the depth of discharge, as well as the rate of discharge. (For specific cycle life numbers for Cyclon and Genesis batteries, please refer to the relevant specification sheets.)

Adequate charging is critical in cyclic applications. In our experience, undercharging is a leading cause of premature bat-

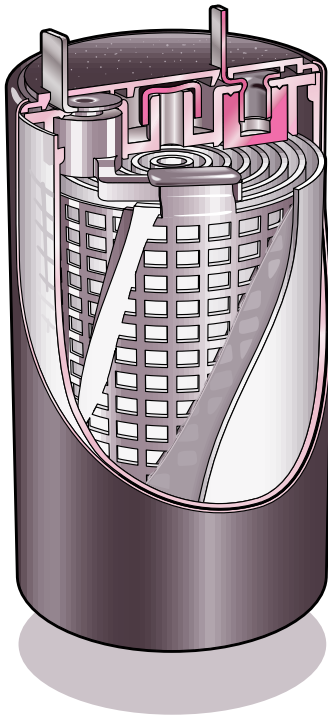
3 A battery has reached "end of life" when it fails to deliver a minimum of 80% of its rated capacity.

4 A battery has "completed a cycle" if it starts out from a full state of charge, completes a discharge and is then fully recharged.



tery failure in cyclic applications. Although overcharge and undercharge are both detrimental to the life of a battery, the impact of undercharging is more acute than that of overcharging. Hence, for cyclic applications, where the calendar life is relatively short, it is very important to ensure that the batteries are not undercharged.

For Cyclon<sup>®</sup> and Genesis<sup>®</sup> product lines, the recommended cyclic charge voltage is about 2.45 vpc. If the current limit is a minimum of 1C, they may be fully recharged from a 100% DOD in 16 hours. If the DOD is less than 100%, the recharge time would be less.



THE CYCLON<sup>®</sup>  
SINGLE CELL

APPLICATION  
TIPS

**T**o get the most out of your batteries, below are some helpful suggestions:

▼ **Be aware of temperature effects**, whether steady-state or excursions. Higher temperatures shorten life, and colder temperatures reduce performance.

▼ **Recharge methods** must keep pace with the expected duty cycle. Undercharging, inadequate charger control and shorter-than-required charge time allowances will all result in acute loss of performance.

▼ **Depth of discharge** will influence product life and duty cycle times.

▼ **Standby charging** must minimize and regulate over-charge currents to provide maximum life.

**W**

hen designing your product, asking yourself the following questions may help better define your power needs:

▼ **Program intent**—What power needs does my product have?

▼ **Customers**—In what type of environments will my customers use my product, and how will those different environments affect the battery's performance?

▼ **Battery features**—What sort of power needs are my customers looking for?

▼ **Charging**—How will my customers charge the battery to ensure maximum performance? What charging requirements will my product need?

▼ **Battery selection**—What size battery (or battery configuration) do I need to power my product? How large does my battery cavity need to be?

▼ **User requirements**—How can I best educate my customers to ensure that they will receive the intended service performance and product life from the battery in my product?

## PRECAUTIONS

**T**he following tips have been provided to help you get the maximum benefit from your batteries, whether in float or cyclic applications:

▼ **Since high temperature** has such a huge impact on a battery's life, every effort must be made to isolate the battery from any heat-producing source such as power transformers. For float applications, temperature compensated chargers are strongly recommended.

▼ **A low voltage disconnect (LVDC)** should be included in the load circuit to isolate the battery when its terminal voltage drops to a predetermined level (see Table I, page 13).

▼ **A battery must not be charged** in a sealed container. Any hydrogen gas evolved during the charging process must be allowed to escape.

▼ **A minimum air space** of 0.15" (3.8mm) must be provided on each side of the battery.

▼ **When installing batteries**, insulating gloves must be worn. All metallic items such as watches, bracelets and other personal jewelry should be removed.

▼ **Only insulated tools** should be used when working on batteries to prevent accidental short circuits.

▼ **Batteries are capable of generating extremely high instantaneous currents** if a short circuiting path between the positive and negative terminals is provided. Such large currents will cause serious personal injury. **DO NOT SHORT CIRCUIT BATTERIES!!**

▼ **Do not mix batteries** of different capacity, age or make in the same system.

▼ **Always use a charging regime** appropriate for the application. If a split rate (multistep) charger is used, the charger must have multiple sense/switch points to assure proper function in all duty cycle scenarios.

▼ **Batteries must always be stored** in a cool, dry area and should be fully charged prior to being placed in storage.

▼ **Sealed-lead rechargeable batteries**, such as Cyclon® and Genesis®, are recyclable. It is recommended that exhausted Cyclon and Genesis batteries be recycled in compliance with local recycling legislation.







*The Power Behind Your Ideas.*

**UL Recognized Component.**

**Cyclon single cells & Genesis meet UL 924 and UL 1778. Cyclon monoblocs meet UL 924.**

The information in this publication is accurate as of its publication date. Specifications are subject to change without notice.

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