genesis® PURELEAD

XE & EP BATTERIES APPLICATION MANUAL

EnerSys® Power/Full Solutions

RESERVE POWER

genesis®
PURELEAD

Preface

This European edition of the Genesis Application Manual introduces the Genesis XE range of batteries, packaged to offer the same superior performance characteristics as the Genesis EP battery in more physically demanding applications such as high temperature and high vibration environments.

Appendix A offers constant current (CC) and constant power (CP) performance data and graphs for the full range of Genesis XE batteries to several end voltages. Appendix B offers the same information for the EP series.

Chapter 4 offers guidelines on the installation, operation and maintenance of Genesis batteries, with the goal of maximising performance and service life.

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Chapter 1:
Introducing the Genesis® Battery

1.1 Background

Since its introduction in the early 1990s, the Genesis® thin plate pure lead-tin (TPPL) battery has established itself as a premium high performance battery suitable for a wide range of demanding applications. Today, TPPL technology can be found in applications as diverse as emergency power, avionics, medical, military and consumer equipment.

The Genesis TPPL battery is offered in either the EP or XE version, and Table 2.2.1 shows the differences between the two versions.

1.2 Transportation classification

Effective September 30, 1995, Genesis batteries were classified as "nonspillable batteries", and are excepted from the Department of Transportation's comprehensive packaging requirements if the following conditions are satisfied: (1)The battery is protected against short circuits and is securely packaged and (2)The battery and outer packaging must be plainly and durably marked "NONSPILLABLE" or "NONSPILLABLE BATTERY".

Genesis batteries have been tested and determined to be in compliance with the vibration and pressure differential tests contained in 49 CFR § 173.159(d).

Because Genesis batteries are classified as "Nonspillable" and meet the conditions above, [from § 173.159(d)] they do not have an assigned UN number nor do they require additional DOT hazard labelling.

1.3 UL component recognition

All Genesis batteries are recognised as UL components.

1.4 Non-halogenated plastics

As the world becomes more environmentally aware, EnerSys® is striving to provide the most environmentally friendly products possible. With this in mind, we are proud to say that the plastics used in our Genesis product line are non-halogenated and therefore do not contain any of the following materials:

- Polybrominated biphenyls (PBB)
- Polybrominated biphenyl ethers (PBBE)
- Polybrominated biphenyloxides (PBBO)
- Polybrominated diphenyl ethers (PBDPE)
- Polybrominated diphenyl oxides (PBDPO)
- Tetrabromobisphenol-A (TBBA)
- Deca-bromo biphenyl ethers (DBBPE's).

The battery meets the non-halogenated flame retardancy requirements of UL 94V-0 by using plastics with non-halogenated flame retardants. Finally, the plastic material used in the manufacturing of Genesis batteries is in full compliance with the German Dioxin Ordinance of 1994.

1.5 Key Genesis benefits

Table 1.5.1 lists some of this battery's features and benefits. The Genesis battery is well suited for any application - high rate, low rate, float or deep discharge cycling.

Table 1.5.1: Key features and benefits of the Genesis battery

Feature	Benefit
High volumetric and gravimetric power densities	More power in less space and weight
Thin-plate design	Superior high rate discharge capability
Low internal resistance	Flatter voltage profile under high-rate discharge; excellent low temperature performance[1]
Negligible gassing under normal charge	Safe for use in human environments such as offices and hospitals. Must be installed in non-gastight enclosures
100% maintenance-free terminals	True fit-and-forget battery
Flexible mounting orientation	Battery may be installed in any position except inverted
Rugged construction	Tolerant of high shock and vibration environments, especially the XE version
Advanced manufacturing techniques	High reliability and consistency
Very high purity lead-tin grid	Lower corrosion rates and longer life
Non-halogenated flame retardant case and cover	Meets UL 94 V-0 requirement, with an LOI >28%
Excellent high-rate recharge capability	Allows >95% recharge in under an hour
Low self-discharge	Longest shelf life among VRLA batteries (2 years at 25°C)
Wide operating temperature	-40°C to +80°C

1 See Table 2.4.1 and Figure 2.4.1 in Section 2.4 of Chapter 2
2 The XE version of the Genesis battery may be used at 80°C when fitted with a metal jacket

Chapter 2:
Technical Information

2.1 Introduction

We have divided this chapter into small sections allowing you to locate the information quickly and easily.

2.2 Choosing the right Genesis® version

As mentioned before, the Genesis® pure lead-tin battery is available in EP and XE versions.

The EP battery is adequate under most operating conditions.
Special application situations such as high ambient temperature or high shock and vibration require the XE version.

Table 2.2.1 summarises the differences between the two versions and is designed to help you choose the right version for your application. In this table, the differences are highlighted in **red boldfaced**.

Table 2.2.1: Choosing the right Genesis® version

Feature	Genesis® EP	Genesis® XE
Technology	Pure lead-tin absorbed glass mat (AGM)	
Float life @ 2.27 volts per cell (Vpc) charge	10 years @ 25ºC	12 years @ 25ºC
Cycle life	400 to 80% depth of discharge (DOD)	
Shock & vibration tolerance	Good	**Better**
Operating temperature range	• -40ºC to +45ºC	• -40ºC to +45ºC
	• -40ºC to +60ºC with metal jacket (denoted EPX)	**• -40ºC to +80ºC with metal jacket (denoted XEX)**
Shelf life @ 25ºC	2 years from 100% charged down to 12V per block	
Capacity @ 10-hr. rate	100% (reference)	≈ 95%
Weight	100% (reference)	≈ 105%
Dimensions	Same footprint	
Quick charge	6C to 8C charge acceptance at 25ºC	
Overdischarge abuse tolerance	Exceeds DIN standard for overdischarge recovery	
High-rate discharge	100% (reference)	≈ 95%
Flame retardant rating	V-0 rated case and cover	
Case & cover colour	Black	Orange
Shipping	Air shippable with no restrictions	

2.3 Battery life

The life expectancy of a Genesis battery depends on the specific application. It is expressed in terms of either cycles or years. While life in years is self-explanatory, a cycle refers to a sequence in which a charged battery is discharged and then charged back up. One complete sequence constitutes one cycle. In general, if the battery is to be discharged frequently, cycle life rather than calendar life is more relevant. On the other hand, if the battery is to be used primarily as power backup, calendar life of the battery should be considered.

In situations where one is not quite sure whether the application is cyclic or standby (float), the following criteria may be used to determine the application category:

- *If the **average** time on charge between two successive discharges is thirty (30) days, the application may be considered to be of a standby (float) nature.*
- *The **minimum** time between two successive discharges must not be less than fourteen (14) days.*

If either of these two criteria is not satisfied, the application should be considered cyclic.

While several factors affect the life of a battery, cycle life depends primarily on the depth of discharge (DOD). At a DOD of 80%, the Genesis® battery will deliver 400 cycles; at 100% DOD, that number decreases to 320 cycles **All cycle life estimates assume adequate full recharge.** Figure 2.3.1 shows the relationship between DOD and cycle life.

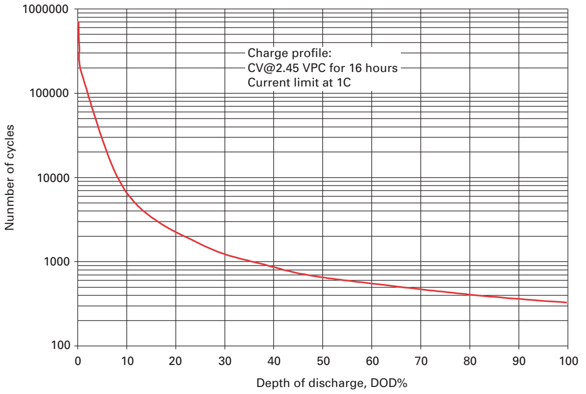


Figure 2.3.1: Cycle life and depth of discharge (DOD)

In contrast to cycle life, ambient temperature dramatically affects float life. For roughly every 8°C rise in ambient temperature above 25ºC, the float life of a VRLA battery is cut in half. In other words, a 10-year battery at 25°C) is only a 5-year battery at 33°C. Additionally, float life is cut in half for every 100mV per cell over the recommended float charge voltage.

The relationship between ambient temperature and expected float life is given by the Arrhenius equation. The equation defines the relationship between the ambient temperature and the rate of internal positive-grid corrosion of the battery, which is the normal process of battery aging.

A key point to note is that the temperature in question is the battery ambient temperature. If the system is in a 25°C environment and the battery is installed next to a power transformer where the temperature averages 32°C, then all battery calculations must be based on 32°C.

The Arrhenius equation is the theoretical foundation for the relationship used in practice to derive the acceleration factor for a given temperature. The equation is shown below, in which AF is the **acceleration factor** and **T** is the battery ambient temperature in ºC.

$$AF = 2^{(0.125T-3.125)}$$

As an example, consider a battery in a float application at an ambient temperature of 37ºC. Replacing T with 37 in the equation above the acceleration factor (AF) in this case would be $2^{(1.5)}$ or 2.83. A 10-year battery in this situation should be expected to last only about 3.5 years (10/2.83 =3.5). Figure 2.3.2 graphically shows the relationship between temperature and float life for the EP and XE series batteries, assuming temperature compensation and a reference temperature of 25ºC.

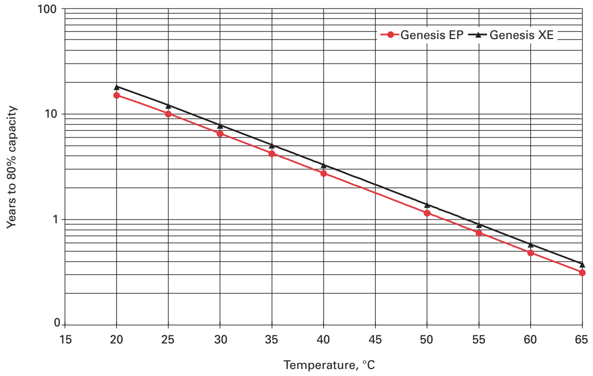


Figure 2.3.2: Battery temperature and float life

2.4 Constant-power and constant-current discharge performance

Batteries are generally required to support either constant-power (CP) or constant-current (CC) loads. CP and CC discharge curves are provided in Appendix A for Genesis® XE and in Appendix B for Genesis EP batteries. The information is provided in both tabular and graphical formats, with each curve representing the discharge profile for a specific model to a specific end voltage.

If intermediate run times are required, such as *watts per battery* for 7 minutes to 1.67 volts per cell, the graphs may be used to estimate the *watts per battery* available.

Generally speaking, most battery systems for indoor applications are in temperature-regulated environments. However, there are occasions when this is not the case. This can happen when the batteries are installed in close proximity to heat generating sources such as transformers. In such cases, the user should know what kind of life to expect from the batteries, since it is well established that a battery's overall life is sensitive to ambient temperature.

In addition to the dependence of battery life on ambient temperature, battery capacity also varies with temperature. Table 2.4.1 shows the variation in battery capacity as a function of the ambient temperature. The capacity at 25ºC is taken as 100%.

Temperature	-20°C	0°C	25°C	40°C	55°C
Capacity @ 15 min. rate	65%	84%	100%	110%	120%

Table 2.4.1: Effect of temperature on 15-minute discharge

A graph of capacity as a function of temperature for the Genesis® battery is shown in Figure 2.4.1 for various rates of discharge.

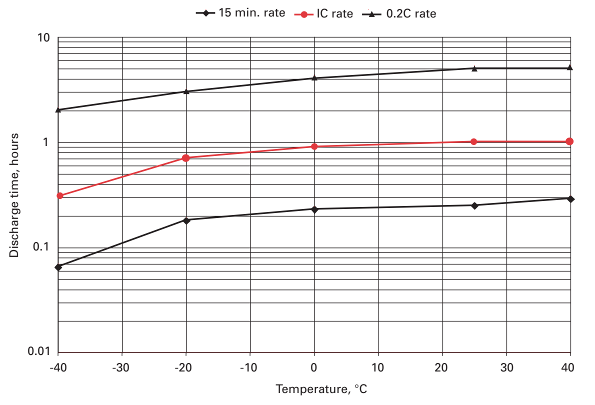


Figure 2.4.1: Capacity as a function of temperature

Although the Genesis battery may be used, with appropriate derating, from -40°C to 80°C, it is strongly recommended that every effort be made to install them in temperature-regulated environments. Metal jackets are required for temperatures exceeding 45°C continuous.

All battery temperatures refer to the temperatures experienced by the active materials ***inside*** the battery. The time required by the active materials to reach thermal equilibrium within the battery environment may be considerable.

2.5 Charging characteristics & requirements

A constant-voltage (CV) regime is the preferred method of charging these batteries, although a constant-current (CC) charger with appropriate controls may also be used.

There is no limit on the magnitude of the charge current during a CV charge. Because of the Genesis battery's low internal resistance, it is able to accept any level of inrush current provided by a constant-voltage charger.

> **Note:** *The following paragraphs on battery charging have been considerably simplified for better understanding. For example, no account has been taken of the polarisation voltage. Second, the battery resistance has been assumed to be static. This is a simplifying assumption since the battery's internal resistance will change continuously during the charge cycle.*

This dynamism in the internal resistance occurs because of the changing state of charge and the fact that the temperature of the active materials within the battery is dynamic.

Owing to these simplifications, the current magnitudes obtained in the sample calculations are exaggerated. However, if one remembers that assumptions have been made and that the *mathematical steps are for illustration only*, then the actual current values calculated become immaterial.

It is known from basic electric-circuit theory that the current in any circuit is directly proportional to the voltage differential in the circuit (Ohm's Law). Therefore, as charging continues at a constant voltage, the charging current decreases due to the decreasing difference between the charger-output voltage and the battery-terminal voltage. Expressed differently, the charging current is at its highest value at the beginning of the charge cycle and at its lowest value at the end of the charge cycle.

Thus, in a CV charge circuit, the battery is the current regulating device in the circuit. It will draw only that amount of current as necessary to reach full charge. Once it attains 100% state of charge, it continues to draw small currents in order to compensate for standing/parasitic losses.

Assume that the battery under consideration has an internal resistance of 4mΩ (0.004Ω) when fully charged. Also, assume that it has an internal resistance of 8mΩ (0.008Ω) when discharged to an end voltage of 10.5 volts. However, the instant the load is removed from the battery, its voltage jumps back up to 12 volts, and this is the initial back electromotive force (EMF) the charger output terminals will see. The influence of this voltage on the charge-current inrush is illustrated in the initial and final charging magnitudes.

It is now decided to recharge the battery at a constant voltage of 2.27 volts per cell or 13.62 volts per battery. Further, assume that when the battery reaches a state of full charge, the internal resistance reduces to 4mΩ and the terminal voltage rises to 13.60V. *For illustrative purposes, this final end-of-charge terminal voltage has been kept deliberately slightly lower than the charging voltage.*

In reality, the charging process is dynamic. As soon as a charging source is placed across the terminals of a discharged battery, its voltage begins rising in an attempt to match the charger-output voltage. Given enough time, one would expect that the battery voltage at some point would exactly equal the charger voltage, thereby reducing the voltage difference in the charging circuit to zero and thus forcing the charge current to zero. However, this does not happen because of the internal electrochemistry, which ensures that the battery will keep drawing small charging currents even when fully charged.

However, almost immediately, the battery self-discharges, depressing its terminal voltage below the charger voltage, thereby initiating a current flow once again. The entire process, as outlined in the previous paragraph, will then repeat itself.

Applying Ohm's Law, which states that *the current in a circuit is equal to the voltage gradient (difference) in the circuit divided by the total resistance in the circuit*, and substituting the various parameters' assumed values, we have the following charging currents. Note that all connection resistances, such as those for cables, are neglected for simplicity. This omission does not affect the outcome since its influence would be the same in both cases, neglecting changes due to electrical heating.

$$\text{Initial charging current} = \frac{13.62 - 12.00}{0.008} = 202.5\text{A}$$

$$\text{Final charging current} = \frac{13.62 - 13.60}{0.004} = 5\text{A}$$

This example shows how the battery acts as a current regulator in a CV charge circuit, decreasing the current flow in the circuit to suit its own state of charge.
Thus, even if the current limit on the charger were 250 amperes, the battery would see an inrush current of 202.5 amperes, before it tapered off and finally dropped to its lowest value at the end of the charge cycle.

Although the 250A figure is impractical because of prohibitive charger costs, it serves to drive home the point that as far as the battery is concerned, a specific current limit is not necessary for Genesis® batteries under CV charging. In reality, the current limit would be dictated by a combination of technical and economic considerations. Note also that, in general, most other battery manufacturers recommend current limits based on battery capacity, usually $0.25C_{10}$, where C_{10} is the 10-hour rating.

Increasing the current limit will reduce the total recharge time, but at greater cost. The reduction in recharge time occurs mainly up to the 90% state of charge level; the impact on total recharge time is much less. The charger-output voltage exercises a much greater influence on the total recharge time.

The question then becomes whether the reduction in the time needed for a recharge can justify the additional costs. In some critical applications, this may be the case, while in other situations the added cost may not be justifiable.

The time to recharge a battery under float charge is shown in Figure 2.5.1. The graphs show the time taken to reach three different states of charge. For example, with a charge current of $0.2C_{10}$ amps the battery will get to 100% SOC in about 12 hours when charged at 13.62V (2.27 Vpc).

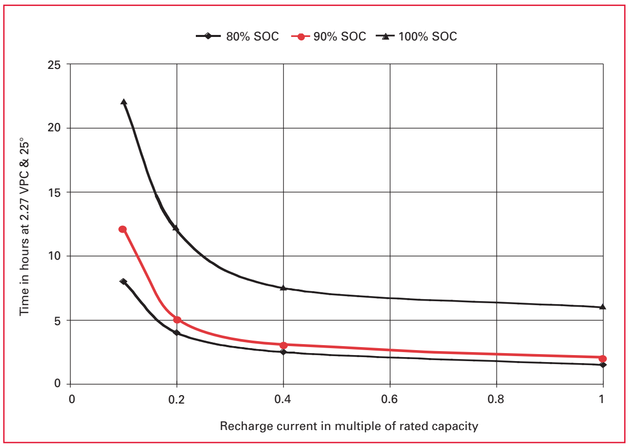


Figure 2.5.1: Recharge times under float charge

2.6 Constant-voltage (CV) regime

In a float or standby application the CV charger should be set at 13.5V to 13.8V at 25°C. For a cyclic application, the charge voltage should be set between 14.4V and 15V at 25°C. In both cases, the linearised temperature compensation factor is ±24mV per battery per °C variation from 25°C. The higher the temperature the lower the charge voltage should be and vice versa.

Figure 2.6.1 shows the temperature compensation factor for float and cyclic applications. Equations representing the compensation curves are also shown in this figure. Note that for both types of application there is no limit on the inrush current. We recommend the highest practical and economical current limit possible.

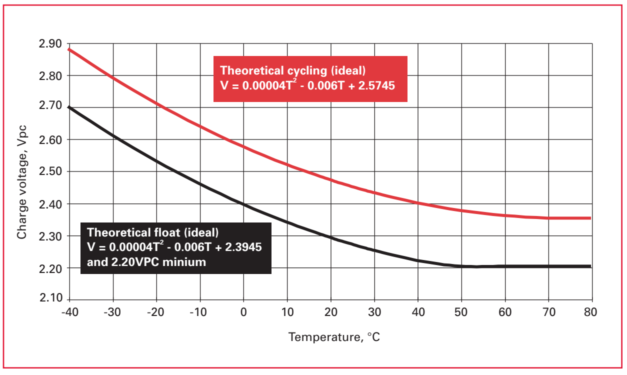


Figure 2.6.1: Temperature compensation graph

2.7 Constant-current (CC) regime

Unlike CV charging, CC charging requires the charge current to be limited to $0.33C_{10}$ to avoid damaging the battery. Once 100% of previously discharged capacity has been returned the overcharge should be continued at a much lower rate, such as $0.002C_{10}$, i.e., at the 500-hour rate.

When using a CC-charge regime, the charge current must switch from a high (starting) rate to a low (finishing) rate when the battery reaches 100% state of charge. The point at which this switch occurs may be determined by using a timer or by sensing the battery voltage.

The timer setting can be determined by calculating the time needed to return 105% to 110% of the ampere-hours drawn out. However, this method should not be used unless the previously discharged capacity can be reliably and consistently measured.

Alternatively, the battery-terminal voltage can be used to trigger the transition from a high charge current to a low charge current. As the battery charges up, its voltage reaches a peak value and then begins to decline to the steady-state, fully charged value. The point at which this drop (point of inflection) begins depends on the charge current's magnitude, as shown in Figure 2.7.1. Since the charge voltages in Figure 2.7.1 are on a per cell basis, simply multiply the numbers by 6 as all Genesis® batteries are 12V units.

The inflection point may be used to switch the current from a high rate (≤ $0.33C_{10}$) to a low rate (≈$0.002C_{10}$). This is a more reliable method than amp-hour counting, as it is independent of the previously discharged capacity.

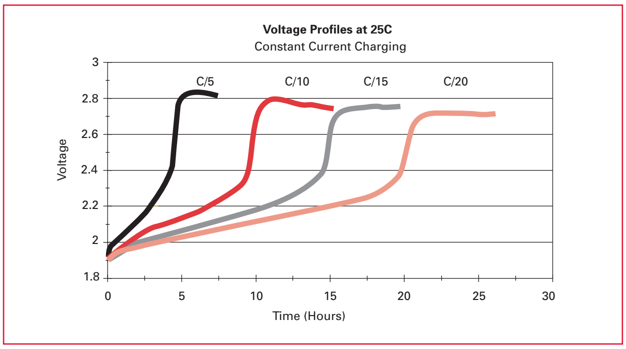


Figure 2.7.1: CC charging curves at 25°C

The Genesis battery may be recharged using either a constant-current (CC) or constant-voltage (CV) charger, ***although the CV regime is the preferred method***. This flexibility in the charging scheme is an advantage, since it is easy for the user to replace existing batteries with Genesis without having to alter the charging circuitry.

Because of the thin plate pure lead-tin technology used in this battery, the internal resistance is significantly lower than that of conventional VRLA batteries. For example, the 26EP battery has an internal resistance of about 5mΩ when fully charged. This compares very favourably with a typical value of 10 to 15mΩ for competitive products of equal capacity.

The low internal resistance helps the Genesis battery accept large inrush currents without any harmful effects. The heat generated by the charge current is kept at a low level because of the very low internal resistance value. The very high recharge efficiency of this battery also allows high inrush currents. In tests performed on the 26Ah product, the initial current drawn by the battery was 175 amperes. The Genesis battery may be recharged much more rapidly than conventional VRLA batteries because of its ability to safely accept very high currents. Table 2.7.1 demonstrates this quick charge capability when using a CV charge of 14.7V.

Capacity returned	Magnitude of inrush current		
	$0.8C_{10}$	$1.6C_{10}$	$3.1C_{10}$
60%	44 min.	20 min.	10 min.
80%	57 min.	28 min.	14 min.
100%	1.5 hrs.	50 min.	30 min.

Table 2.7.1: Inrush current and charge time

This fast-charge capability is remarkable in a VRLA battery. This feature makes the Genesis battery competitive with a nickel-cadmium battery, which traditionally had an advantage over lead acid batteries due to its short charge times.

The quick charge capability of the Genesis battery makes it particularly suitable for applications where the battery has to be returned quickly to a high state of charge after a discharge.

2.8 Three-step (IUU) charge profile

A three-step charge profile developed for use with the Genesis TPPL battery is shown in Figure 2.8.1. The first step (bulk charge) is a constant current (CC) charge with a minimum current of 40% of the 10-hour (C_{10}) rating of the battery. For example, to use this profile effectively on the 16Ah battery, the minimum charge current must be 6.4 amps.

Bulk charge continues until the battery voltage reaches 14.7V. The charger then switches to a constant voltage (CV) mode at 14.7V and the absorption charge phase begins.

The charger switches to the temperature-compensated float phase when either the current drops to 25% of the bulk charge current ($0.1C_{10}$ amps) or the time in the absorption phase reaches 8 hours, whichever occurs first.

If the charger has a timer override so that the absorption phase does not exceed 8 hours, the threshold current at which the charger switches from absorption phase to float phase should be reduced to $0.001C_{10}$. This equals 16mA for the 16Ah battery discussed in the earlier example.

If the charger does not have a timer the trigger to switch from absorption phase to float phase should be set at $0.1C_{10}$.

> **Note:** *The battery will not be fully charged when a switch from absorption to float charge is made when the current drops to 0.1C10. The battery will need a minimum of 16-24 hours on float charge before it is fully charged. The battery may be used as soon as the switch to float is made, but repeatedly cycling it without the necessary 16-24 hours' on float charge will cause premature failure of the battery.*

Alternatively, the charger can stay in the absorption phase for a fixed 8 hours. Once this absorption charge time is over, the charger can switch to a temperature-compensated float voltage. The advantage with this design is a less complex circuit because it is not necessary to monitor the charge current in the absorption phase.

Table 2.8.1 lists the different IUU charge profile options. A check mark indicates the feature is available in the charger, while X indicates a charger that does not have the feature. Note that all three designs have bulk, absorption and float charge phases. The differences between the three designs are limited to (a) whether a timer is available, (b) whether the circuit monitors the charge current and (c) the magnitude of the threshold current, if it is used to trigger the switch from absorption charge to float charge.

Table 2.8.1: IUU charger design options

	Feature				
	Bulk	Absorption	Timer	Trigger	Float
Design 1	✓	✓	✓	$0.001C_{10}$ amps	✓
Design 2	✓	✓	✓	X	✓
Design 3	✓	✓	X	$0.10C_{10}$ amps	✓

Design 1:

The charger has a timer and a current threshold that triggers the switch from absorption charge to float charge. Since the timer is present, the trigger current is set low. If the current does not drop to $0.001C_{10}$ amps within 8 hours on absorption charge, the timer will force the switch to a temperature-compensated float charge.

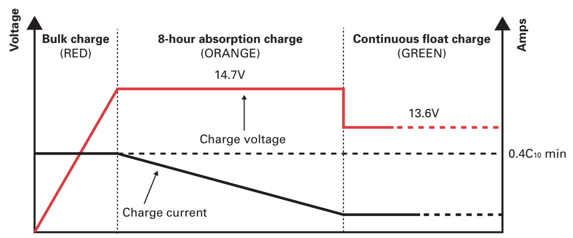
Design 2:

The charger does not switch to a float charge based on a preset charge current. Rather, the timer stays in the absorption phase for 8 hours before switching to a temperature-compensated float charge.

Design 3:

The charger has no timer. Since switching depends solely on the charge current dropping to a set level, the threshold is set high enough to ensure the charger will always switch to a float charge. In this design the battery will not be fully charged at the start of the float charge. ***A minimum of 16-24 hours on float will be required to complete the charge.***

Figure 2.8.1: Three-step (IUU) charge profile



NOTES:
1. Charger LED stays RED in bulk charge phase (DO NOT TAKE BATTERY OFF CHARGE)
2. LED changes to ORANGE in absorption charge phase (BATTERY AT 80% STATE OF CHARGE)
3. LED changes to GREEN in float charge phase (BATTERY FULLY CHARGED)
4. Charge voltage is temperature compensated at ±24mV per battery per °C variation from 25°C

2.9 Storage characteristics

Improper storage is a common form of battery misuse. High storage temperature and inadequate frequency of freshening charges are examples of improper storage. In order to better understand the various mechanisms influencing sealed-lead batteries kept in storage, the following paragraphs discuss in general terms several aspects of the batteries' storage requirements.

2.10 Self discharge

All batteries lose charge over time when kept on open circuit. This phenomenon is termed *self-discharge*.

If the capacity loss due to self-discharge is not compensated by recharging in a timely fashion, the capacity loss may become irrecoverable due to irreversible sulphation, where the active materials (PbO_2, lead dioxide, at the positive plates and sponge lead at the negative plates) are gradually converted into an electroinactive form of lead sulphate, $PbSO_4$. If the capacity loss associated with self-discharge is not replenished, the battery ultimately fails because storage is electrochemically equivalent to a very low rate of discharge.

Storage temperature is the key factor influencing the self-discharge rate because it plays a major role in determining the speed at which the internal chemical reaction proceeds. The higher the temperature, the faster the speed of chemical reactions.

Just as every 8°C rise in operating temperature cuts the battery's life expectancy in half, so does every 8°C increase in ambient temperature reduce the storage life of a battery by 50%. Conversely, a reduction in storage temperature will have the reverse effect by increasing the allowable storage time.

2.11 Open circuit voltage (OCV) and state of charge (SOC)

Since most batteries are subject to some kind of storage, it is important for the user to have some method of accurately estimating the battery capacity after it has been in storage.

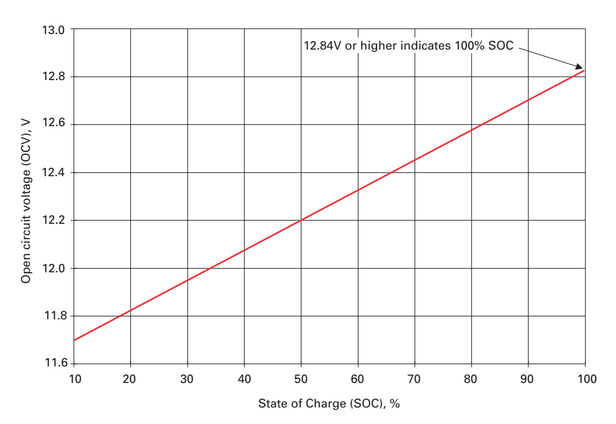


Figure 2.11.1: Open circuit voltage and state of charge

Although efforts should be made to ensure that batteries are stored in temperature-controlled environments, a freshening charge should be applied once every twenty-four (24) months or when the open-circuit voltage (OCV) reading drops to 12V, whichever comes first. As shown in Figure 2.11.1, 12V corresponds to a 35% state of charge (SOC). ***The battery may be permanently damaged if the OCV is allowed to drop below 11.90V.***

Figure 2.11.1 shows the OCV and corresponding SOC for a Genesis battery. An OCV of 12.84V or more indicates a battery at 100% SOC. The figure is accurate to within 20% of the true SOC of the battery ***if the battery has not been charged OR discharged in the 24 hours preceding the voltage measurement***. The accuracy improves to 5% if the period of inactivity before the voltage measurement is 5 days.

Capacity loss during storage is an important consideration, particularly in applications where performance loss due to storage is unacceptable. However, knowing how much charge is remaining in the battery at any point in its storage life is equally important as the battery must be maintained at a minimum charge level in order to prevent permanent damage. Figure 2.11.2 shows the relationship between storage time and remaining capacity at 25°C, 45°C and 65°C.

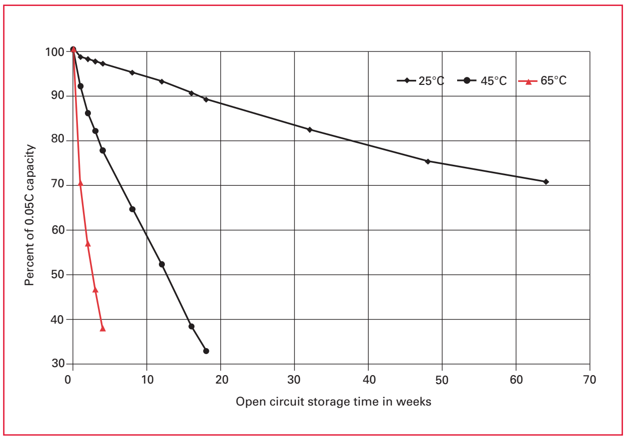


Figure 2.11.2: Storage capacity at temperatures

2.12 Procedure to recover overdischarged batteries

There may be instances when a Genesis® battery is overdischarged to the point where a standard charger is unable to fully recharge the battery. In such cases, the following procedure may help recover the affected battery.

1. Bring the battery to room temperature (25°C).
2. Measure the OCV. Continue to step 3 if it is at least 12V; otherwise terminate the procedure and reject the battery.
3. Charge the battery using a $0.05C_{10}$ constant current for 24 hours. The charger should be capable of providing a driving voltage as high as 36V. Monitor the battery temperature; ***discontinue charging if the battery temperature rises above 45°C***.
4. Allow the charged battery to stand on open circuit for a minimum of 1 hour before proceeding to Step 5.
5. Perform a capacity test on the battery and record the amp-hours delivered. The longer the discharge the more reliable the result. This is Cycle 1.
6. Repeat steps (3) to (5). The capacity returned in step 5 is now Cycle 2. If Cycle 2 capacity is greater than Cycle 1 capacity proceed to step 7; otherwise reject the battery.
7. Repeat steps (3) to (5) to get Cycle 3 capacity. Proceed to step 8 if Cycle 3 capacity is equal to or more than Cycle 2 capacity. Reject the battery if Cycle 3 capacity is less than Cycle 2 capacity.
8. If Cycle 3 capacity equals or exceeds Cycle 2 capacity, recharge the battery and put it back in service.

Chapter 3:
General Test Data

3.1 Introduction

This section's purpose is to discuss actual data from various tests conducted on Genesis® batteries. These tests may be of particular interest to system designers and application engineers. Other test results serve to confirm the data published in the ***Genesis Selection Guide***.
Tests covered in this chapter include the following:

- Thermal runaway test
- Altitude test
- Overdischarge recovery tests (DIN standard test and high temperature storage test)
- Accelerated float life test
- Gassing test
- Performance test at different temperatures

3.2 Thermal runaway test

Thermal runaway (TR) describes a situation in which the battery is unable to maintain a steady current when connected to a CV charger. TR can also happen when the battery temperature increases rapidly due to inadequate heat dissipation from the battery.

As the battery draws current, its internal temperature rises. If the heat generated is not dissipated, the internal reaction rate of the battery will increase, forcing the battery to draw more current. This in turn generates more heat. The increasing heat generation and attendant higher current draw feed on each other which, if allowed to escalate will trigger TR.

Figure 3.2.1 shows the result of TR tests conducted on a 12V, 26EP Genesis TPPL battery that had been cycled 10 times to age it. After the tenth discharge the battery was fully charged using normal charging parameters, then put on a gross overcharge at 15.9V (2.65 VPC) at 25°C.

The threshold criterion for initiation of TR was set at a charge current of 4.5 amps or a battery temperature of 60°C. In other words, the battery was considered to be in TR when either the charge current reached 4.5 amps or the battery case temperature rose to 60°C. As shown in Figure 3.2.1 the battery reached the temperature threshold first, after the battery had been on overcharge for 370.9 hours, or over 15 days.

Two points are noteworthy here. First, it took over 15 days on gross overcharge (remember, the battery was fully charged when it was placed on a 15.9V charge) before it showed signs of going into TR. The battery received a staggering 565.7 amp-hours (over 2,000% of its rated capacity) during the test.

Second, there was no catastrophic failure of the battery and its case temperature rose gradually. It took over a week (169 hours) for the temperature to rise from 45°C to 60°C. The results of this test clearly show that even in the unlikely event of a Genesis battery going into TR, its behaviour does not raise safety issues.

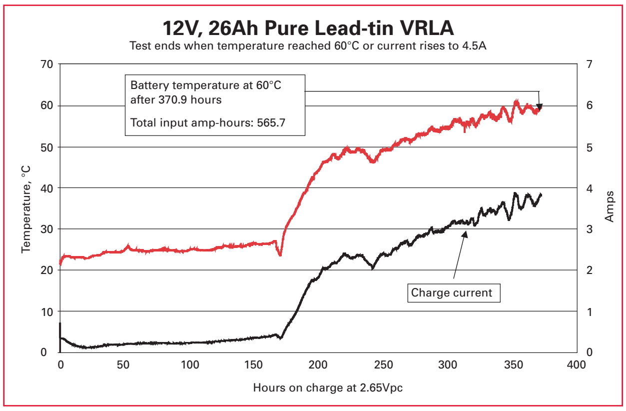


Figure 3.2.1: TR test at 15.9V (2.65Vpc) charge

3.3 Gassing test

The Genesis battery is safe for use in human environments, such as offices and hospitals. A test was developed to determine how much hydrogen gas is evolved under normal operating conditions. This test's assumption is that any weight loss suffered by the battery can be attributed to the water lost by the battery. Knowing the amount of water lost by the battery and the chemical composition of water, a relatively straightforward calculation yields the amount of emitted hydrogen gas. Table 3.3.1 summarises the test data on a Genesis 26Ah battery.

Test temperature	60°C
Charge voltage	2.30 Vpc
Duration of test at temperature	180 days
Weight loss at end of test period	65.6 grams = 3.65 moles (gram equiv.) H_2O = 3.65 moles H_2 and 1.82 moles O_2
Gas evolved	Total 122.6 litres
Duration of test at 25°C	2,880 days (4,147,200 minutes)
Gassing rate	Total 0.03 cc/min Hydrogen (H_2): 0.02 cc/min.

Table 3.3.1: Gassing test data

The oxygen evolved is recombined, while the rate of hydrogen emission is negligible, as Table 3.3.1 shows. Nevertheless, the battery should not be recharged in a gas-tight container. Ventilation must always be provided in the charging area.

3.4 DIN standard overdischarge recovery test

This German standard test was designed to determine the ability of batteries to recover from overdischarge using standard chargers. In addition, the test also gives an indication of the resistance of the battery to permanent damage caused by sulphation, a phenomenon that occurs when a battery is left in a discharged condition for an extended length of time.

The test began by discharging a fully charged 26Ah battery at the 20-hour rate to 1.70 Vpc. Following the discharge, a 5Ω resistor was connected across the battery terminals and left connected for 28 days. At the end of this 28-day period, the battery was recharged at a constant voltage of 2.25 Vpc for only 48 hours.

The battery was tested for capacity after the 48-hour recharge, and 97% of the initial capacity was obtained. A subsequent recharge/discharge cycle yielded a capacity of 94% of the initial capacity. The overdischarge test exercise is summarised in Table 3.4.1 below.

Conditions	$0.05C_{10}$ rate discharge to 1.70 Vpc
Followed by	5Ω resistor connected across battery terminals for 28 days
Recharge	2.25 Vpc CV charge for 48 hours
Results	Initial capacity: 26.8Ah
Recovered capacity	25.9Ah (97%) on first cycle 25.3Ah (94%) on second cycle

Table 3.4.1: DIN standard overdischarge recovery test result

3.5 High temperature storage recovery test

This test demonstrates the deep discharge recovery capability of the Genesis® battery. Since the test involves storing the battery in a discharged state for 4 weeks at 50ºC it is a more difficult test than the previously described German DIN standard test. Figure 3.5.1 summarises the test results.

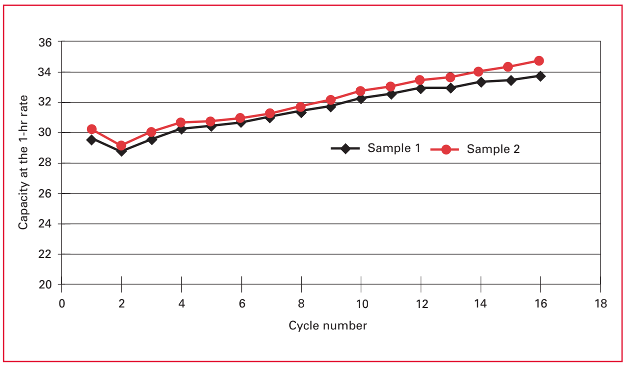


Figure 3.5.1: Recovery from discharged storage at 50ºC

Both samples were discharged at the 1-hour rate to an end of discharge voltage of 9V, then stored in a discharged condition for 4 weeks at 50ºC.
The batteries were then charged at 14.7V with a current limit of $0.125C_{10}$ for the first two cycles and $1C_{10}$ for cycles 3 through 17.

It is clear that the charge current was too low for the first two cycles, as evident from the rapid loss in capacity. Boosting the charge current to $1C_{10}$ brought both batteries back to full capacity.

3.6 Altitude test

This test was designed to prove that the Genesis battery is capable of operating safely and without performance loss at any altitude. Since the design of the Genesis battery's Bunsen valve does not rely on atmospheric pressure to operate, the battery will operate over a wide range of external pressure, from vacuum to as much as 100 feet under water.

These batteries have also passed the pressure differential test required to comply with the requirements of DOT HMR 49 Non-Hazardous Materials, International Civil Aeronautics Organisation (ICAO) and International Air Transport Association (IATA) Packing Instruction 806 and Special Provision A67.

In the pressure differential test, the battery is placed in a temperature-controlled altitude chamber at 24°C.
It is then subjected to 6 hours of differential pressure at a minimum of 88 kPa (equivalent to an altitude of 50,000 feet). The test is repeated for each of three mutually perpendicular orientations, including the inverted position. A visual inspection showed no acid leakage, indicating the battery passed the test.

Section 3.7: Accelerated float life test

Figure 3.7.1 shows the results of accelerated float life (AFL) tests conducted on three samples of the Genesis 16Ah battery. In AFL tests, high temperatures accelerate the aging process of the batteries. At an AFL test temperature of 55ºC, the acceleration factor (AF) is 13.454, which means that every day at 55ºC is electrochemically equivalent to 13.454 days at 25ºC. This is a conservative AF because the charge voltage used in the test is not temperature-compensated, as it should be. No account is taken of the accelerated aging of the battery due to a higher-than-recommended charge voltage.

As shown in Figure 3.7.1 the three batteries were at 109%, 108% and 110% of their rated capacity after 270 days on test at 55ºC. This is electrochemically equivalent to 9.95[1] years on float at 25ºC. Since end of life is defined as the failure to deliver 80% of its rated capacity, none of these batteries is close to the end of its design life of 10 years at 25ºC.

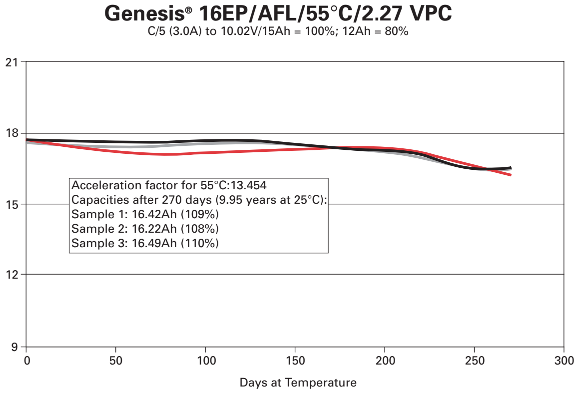


Figure 3.7.1: AFL test data for Genesis® 16EP batteries

Similar tests on the Genesis® XE batteries showed an average float life of 454 days at 55°C, or the equivalent of 16.7 years at 25°C to 80% of rated capacity. These results validate the Genesis EP and XE published design life of 10 years and 12+ years, respectively, at 25°C to 80% of rated capacity.

Section 3.8: Performance test at different temperatures

Figure 3.8.1 shows the effect of temperature on the discharge performance of Genesis batteries at three rates of discharge. The vertical broken line represents 25°C, and its intersections with the graphs show the 100% capacity at the three rates of discharge.

At –40°C, the battery will run for 2 hours at the C_5 rate (60% of its 5-hour capacity), for 18 minutes at the C_1 rate (30% of its 1-hour capacity) and for 4 minutes at the 15-minute rate (27% of its 15-minute capacity). These are excellent performance numbers, considering how low the ambient temperature is.

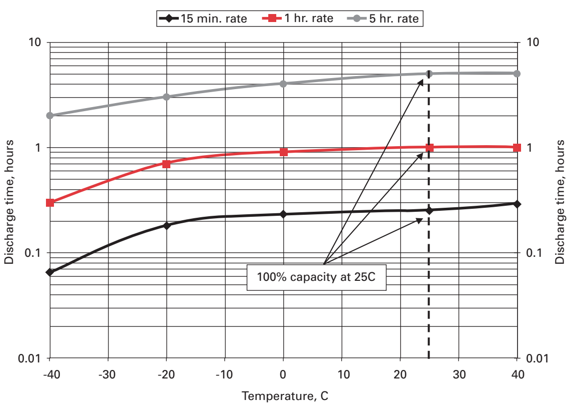


Figure 3.8.1: Effect of temperature on capacity

Chapter 4: Installation, Operation & Maintenance

4.1 Introduction

This chapter is designed to provide the user with guidelines to help get the most out these batteries. Even though VRLA batteries do not require the addition of water, periodic maintenance checks are strongly recommended. These are:

- *Individual unit voltages*
- *Unit-to-unit connection resistances*
- *Ambient temperature and battery temperature*

A load test can be carried out once or twice a year. The batteries must be fully charged before any capacity test is performed.

4.2 Receiving the shipment

All batteries must be carefully inspected upon arrival for any sign of damage during their transportation. Use rubber gloves when handling any that are broken or physically damaged in case of acid leakage.

4.3 Storage

All Genesis batteries must be stored in a clean and dry location, and preferably in a temperature-controlled environment. Although these batteries are shipped fully charged and may be stored for up to 2 years at 25°C periodic checks of their open circuit voltages are recommended. The warmer the storage environment the more frequent the voltage checks should be.

The batteries must be given a freshening charge once every 2 years or when the OCV drops to 12.00V, whichever occurs earlier. The freshening charge should be for 96 hours at 13.62V at 25°C or until the charge current does not vary over a 3-hour period. Alternatively, the freshening charge can be set at 14.4V for 16 to 24 hours or until the charge current does not vary over a 3-hour period.

Failure to observe these conditions may result in greatly reduced capacity and service life. **FAILURE TO CHARGE AS NOTED VOIDS THE BATTERY'S WARRANTY.**

4.4 Installation

Batteries must be installed in a clean, dry area. Genesis batteries release negligible amounts of gas during normal operation (gas recombination efficiency ≥99%), making them safe for installation near main equipment and in close proximity to humans. Batteries must be installed in accordance with BS 6133 or EN 50272.

4.4.1 Temperature

Avoid placing batteries in areas of high temperature or in direct sunlight. The optimal temperature range for performance and service life of the Genesis® battery is 20ºC to 25ºC. These batteries can, however be used at temperatures ranging from -40ºC to 80ºC when fitted with a metal jacket.

4.4.2 Ventilation

As stated before, under normal operating conditions the gas emission from Genesis batteries is very low. Natural ventilation is adequate for cooling and to prevent buildup of hydrogen gas. This is why Genesis batteries may be used safely in offices, hospitals and other occupied environments.

When installing batteries in cabinets or other enclosures, care must be taken to ensure they are not sealed enclosures. **UNDER NO CIRCUMSTANCES SHOULD THESE BATTERIES BE CHARGED IN A SEALED CONTAINER.**

All installations and ventilation must comply with BS 6133 or EN 50272.

4.4.3 Mounting

Check that all contact surfaces are clean before making the interbattery connections.

Tighten the screws to the recommended torque value using insulated tools only and follow the polarities of individual batteries to avoid short circuits. Finally, connect the battery end terminals.

Since the Genesis battery has all of its electrolyte immobilised in its separators, it can be mounted on its sides without any performance degradation.

Note: The safety standards of EN 50272.

4.4.4 Torque

The recommended terminal torque for the full range is given in Table 4.4.5.1. A loose connector can cause problems in charger performance, erratic battery performance, possible damage to the battery and even personal injuries.

Only use insulated tools when working on batteries.

Battery model	Terminal torque
13EP & XE13	5.6 Nm
16EP & XE16	5.6 Nm
26EP & XE30	6.8 Nm
42EP & XE40	6.8 Nm
70EP & XE70	6.8 Nm
- XE95	6.8 Nm

Table 4.4.5.1: Terminal torque values

4.5 Parallel strings

While there are no theoretical limits on the number of parallel battery strings, we recommend no more than 6 parallel strings per system, particularly for cyclic applications.

4.6 Discharging

It is strongly recommended that a low voltage cutoff be included in the battery load circuit to protect the battery from overdischarges. The setting for end of discharge voltage (EODV) is dependent on the rate of discharge, as shown in Table 4.6.1. For optimum battery life, we recommend that the battery be disconnected from the load when the appropriate voltage is reached and put back on charge as soon as possible after a discharge.

Discharge rate in amps	Suggested minimum EODV
$0.05C_{10}$ ($C_{10}/20$)	10.50V
$0.10C_{10}$ ($C_{10}/10$)	10.20V
$0.20C_{10}$ ($C_{10}/5$)	10.02V
$0.40C_{10}$ ($C_{10}/2.5$)	9.90V
$1C_{10}$	9.60V
$2C_{10}$	9.30V
$>5C_{10}$	9.00V

Table 4.6.1: Suggested battery cutoff voltages

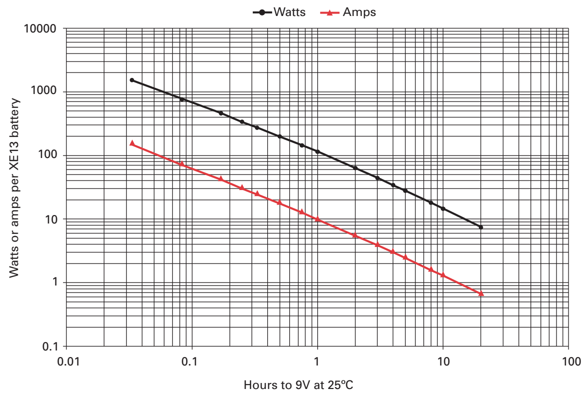
Note: *Discharging the Genesis battery below these low voltage cutoff levels or leaving the battery connected to a load in a discharged state may impair the battery's ability to accept a charge.*

Appendix A - Genesis® XE Discharge Rates

genesis
PURELEAD

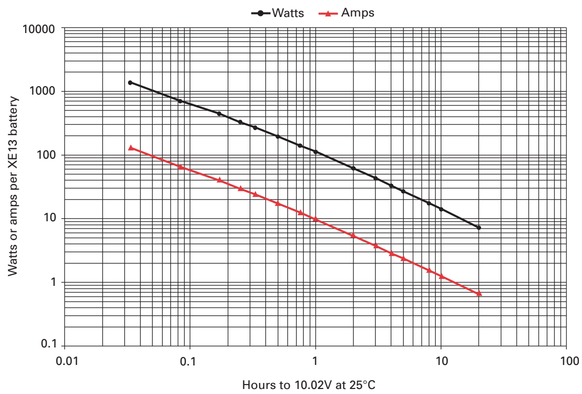
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1529	149.1	5.0	50.9	764.8	25.5	283.1	9.4
5 min.	760	71.2	5.9	63.3	400.2	33.3	140.7	11.7
10 min.	460	41.7	7.1	78.2	242.3	41.2	85.2	14.5
15 min.	339	30.2	7.6	84.8	178.8	44.7	62.8	15.7
20 min.	273	24.1	7.9	90.0	143.7	47.4	50.5	16.7
30 min.	199	17.4	8.7	99.4	104.7	52.4	36.8	18.4
45 min.	144	12.5	9.4	108.0	75.9	56.9	26.7	20.0
1 hr.	114	9.8	9.8	113.6	59.9	59.9	21.0	21.0
2 hr.	64	5.4	10.9	127.1	33.5	66.9	11.8	23.5
3 hr.	44	3.8	11.4	132.9	23.3	70.0	8.2	24.6
4 hr.	34	3.0	11.8	137.0	18.0	72.2	6.3	25.4
5 hr.	28	2.4	12.0	139.7	14.7	73.6	5.2	25.9
8 hr.	18	1.6	12.6	144.3	9.5	76.0	3.3	26.7
10 hr.	15	1.3	12.7	145.5	7.7	76.7	2.7	26.9
20 hr.	7	0.7	13.2	148.0	3.9	78.0	1.4	27.4

Figure A-1: XE13 discharge data to 9.0V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1361	128.0	4.3	45.3	680.8	22.7	252.0	8.4
5 min.	701	64.4	5.4	58.4	369.4	30.8	129.8	10.8
10 min.	443	39.6	6.7	75.2	233.2	39.6	82.0	13.9
15 min.	330	29.2	7.3	82.6	174.1	43.5	61.2	15.3
20 min.	267	23.5	7.7	88.1	140.7	46.4	49.4	16.3
30 min.	195	16.9	8.5	97.5	102.7	51.4	36.1	18.1
45 min.	141	12.2	9.1	105.7	74.2	55.7	26.1	19.6
1 hr.	111	9.6	9.6	111.2	58.6	58.6	20.6	20.6
2 hr.	62	5.3	10.6	123.4	32.5	65.0	11.4	22.8
3 hr.	43	3.7	11.1	128.7	22.6	67.8	7.9	23.8
4 hr.	33	2.9	11.5	132.3	17.4	69.7	6.1	24.5
5 hr.	27	2.3	11.7	134.8	14.2	71.0	5.0	25.0
8 hr.	17	1.5	12.1	138.9	9.1	73.2	3.2	25.7
10 hr.	14	1.2	12.4	140.6	7.4	74.1	2.6	26.0
20 hr.	7	0.7	13.0	144.3	3.8	76.0	1.3	26.7

Figure A-2: XE13 discharge data to 10.02V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1206	111.0	3.7	40.1	603.3	20.1	223.3	7.4
5 min.	662	58.9	4.9	55.2	348.9	29.1	122.6	10.2
10 min.	429	37.3	6.3	72.9	225.9	38.4	79.4	13.5
15 min.	323	28.0	7.0	80.7	170.2	42.5	59.8	15.0
20 min.	262	22.6	7.5	86.3	137.8	45.5	48.4	16.0
30 min.	191	16.5	8.3	95.6	100.8	50.4	35.4	17.7
45 min.	138	12.0	9.0	103.8	72.9	54.7	25.6	19.2
1 hr.	109	9.4	9.4	108.7	57.3	57.3	20.1	20.1
2 hr.	60	5.2	10.4	119.3	31.4	62.9	11.0	22.1
3 hr.	41	3.6	10.9	124.2	21.8	65.5	7.7	23.0
4 hr.	32	2.8	11.3	127.4	16.8	67.1	5.9	23.6
5 hr.	26	2.3	11.5	129.6	13.7	68.3	4.8	24.0
8 hr.	17	1.5	11.9	133.5	8.8	70.4	3.1	24.7
10 hr.	14	1.2	12.1	135.1	7.1	71.2	2.5	25.0
20 hr.	7	0.6	12.8	140.6	3.7	74.1	1.3	26.0

Figure A-3: XE13 discharge data to 10.5V at 25°C

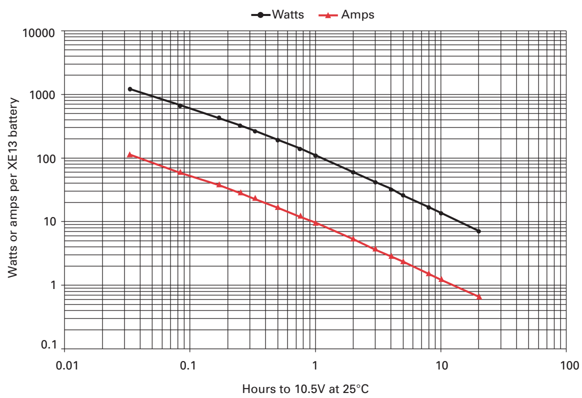
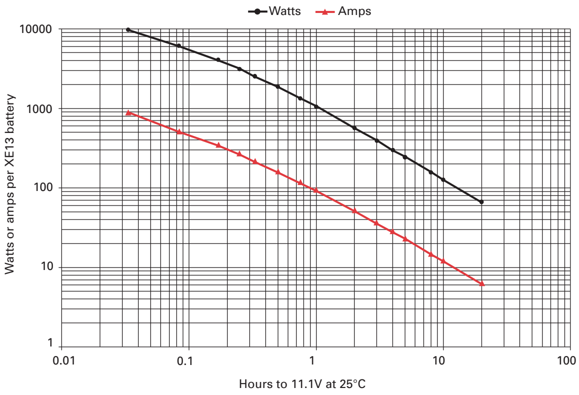
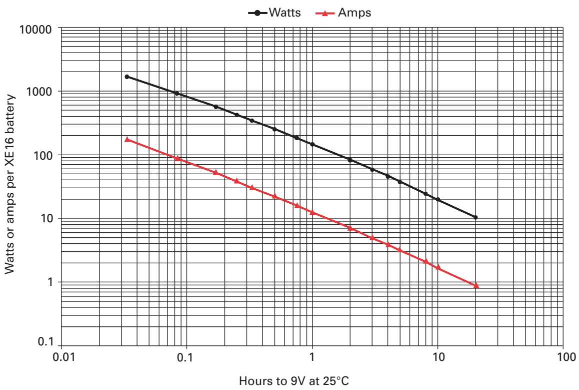


Figure A-4: XE13 discharge data to 11.1V at 25°C



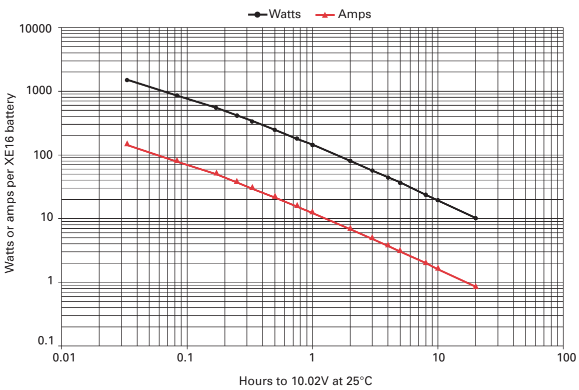
Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	977	87.1	2.9	32.5	488.7	16.3	180.9	6.0
5 min.	612	51.1	4.3	51.0	322.6	26.9	113.4	9.4
10 min.	410	34.0	5.8	69.7	216.0	36.7	75.9	12.9
15 min.	312	26.0	6.5	78.0	164.4	41.1	57.8	14.4
20 min.	254	21.3	7.0	83.7	133.7	44.1	47.0	15.5
30 min.	186	15.8	7.9	93.1	98.1	49.1	34.5	17.2
45 min.	133	11.4	8.6	100.1	70.3	52.7	24.7	18.5
1 hr.	105	9.1	9.1	104.9	55.3	55.3	19.4	19.4
2 hr.	57	5.1	10.1	113.4	29.9	59.7	10.5	21.0
3 hr.	39	3.5	10.6	117.2	20.6	61.8	7.2	21.7
4 hr.	30	2.7	11.0	119.8	15.8	63.1	5.5	22.2
5 hr.	24	2.2	11.2	121.3	12.8	63.9	4.5	22.5
8 hr.	16	1.5	11.6	124.7	8.2	65.7	2.9	23.1
10 hr.	13	1.2	11.8	126.6	6.7	66.7	2.3	23.4
20 hr.	7	0.6	12.4	133.3	3.5	70.2	1.2	24.7

Figure A-5: XE16 discharge data to 9V at 25°C



Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1674	170.0	5.6	55.8	720.0	24.0	261.6	8.7
5 min.	915	87.9	7.3	76.3	393.6	32.8	143.0	11.9
10 min.	566	52.0	8.8	96.2	243.4	41.4	88.4	15.0
15 min.	422	38.0	9.5	105.4	181.4	45.3	65.9	16.5
20 min.	342	30.3	10.0	112.7	146.8	48.5	53.4	17.6
30 min.	251	22.0	11.0	125.4	107.8	53.9	39.2	19.6
45 min.	183	15.8	11.8	137.5	78.8	59.1	28.6	21.5
1 hr.	145	12.4	12.4	145.3	62.5	62.5	22.7	22.7
2 hr.	82	7.0	13.9	164.1	35.3	70.6	12.8	25.6
3 hr.	58	4.9	14.7	174.7	25.0	75.1	9.1	27.3
4 hr.	45	3.8	15.3	181.4	19.5	78.0	7.1	28.3
5 hr.	37	3.1	15.6	186.2	16.0	80.1	5.8	29.1
8 hr.	24	2.1	16.4	195.2	10.5	83.9	3.8	30.5
10 hr.	20	1.7	16.7	198.7	8.5	85.4	3.1	31.0
20 hr.	10	0.9	17.3	206.7	4.4	88.9	1.6	32.3

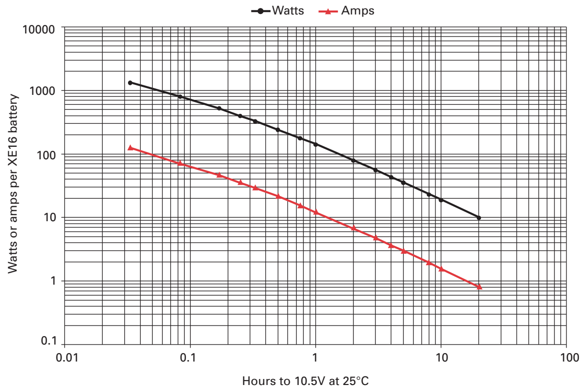
Figure A-6: XE16 discharge data to 10.02V at 25°C



Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1486	143.0	4.8	49.5	638.8	21.3	232.1	7.7
5 min.	857	78.8	6.6	71.4	368.5	30.7	133.9	11.2
10 min.	546	49.3	8.4	92.9	234.9	39.9	85.3	14.5
15 min.	412	36.7	9.2	102.9	177.0	44.2	64.3	16.1
20 min.	335	29.6	9.8	110.4	143.9	47.5	52.3	17.2
30 min.	247	21.6	10.8	123.5	106.2	53.1	38.6	19.3
45 min.	180	15.6	11.7	135.1	77.5	58.1	28.2	21.1
1 hr.	143	12.3	12.3	142.8	61.4	61.4	22.3	22.3
2 hr.	81	6.9	13.7	161.6	34.7	69.5	12.6	25.3
3 hr.	57	4.8	14.4	170.5	24.4	73.3	8.9	26.6
4 hr.	44	3.7	14.8	176.8	19.0	76.0	6.9	27.6
5 hr.	36	3.0	15.2	181.0	15.6	77.8	5.7	28.3
8 hr.	24	2.0	15.7	189.3	10.2	81.4	3.7	29.6
10 hr.	19	1.6	16.0	193.2	8.3	83.1	3.0	30.2
20 hr.	10	0.8	16.7	201.8	4.3	86.8	1.6	31.5

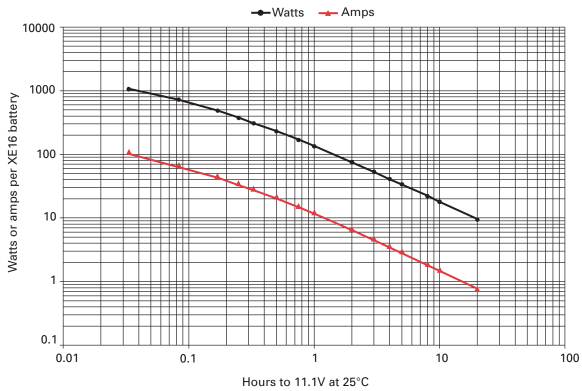
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1312	124.9	4.2	43.7	564.3	18.8	205.1	6.8
5 min.	799	71.8	6.0	66.5	343.4	28.6	124.8	10.4
10 min.	522	46.5	7.9	88.8	224.6	38.2	81.6	13.9
15 min.	397	35.1	8.8	99.3	170.7	42.7	62.0	15.5
20 min.	324	28.6	9.4	106.9	139.3	46.0	50.6	16.7
30 min.	240	21.0	10.5	120.1	103.3	51.6	37.5	18.8
45 min.	176	15.2	11.4	131.8	75.6	56.7	27.5	20.6
1 hr.	140	12.0	12.0	139.7	60.1	60.1	21.8	21.8
2 hr.	78	6.7	13.3	156.7	33.7	67.4	12.2	24.5
3 hr.	55	4.7	14.0	166.1	23.8	71.4	8.6	25.9
4 hr.	43	3.6	14.4	172.1	18.5	74.0	6.7	26.9
5 hr.	35	2.9	14.7	176.1	15.1	75.7	5.5	27.5
8 hr.	23	1.9	15.2	183.9	9.9	79.1	3.6	28.7
10 hr.	19	1.6	15.5	187.7	8.1	80.7	2.9	29.3
20 hr.	10	0.8	16.1	196.9	4.2	84.7	1.5	30.8

Figure A-7: XE16 discharge data to 10.5V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1058	100.4	3.3	35.2	454.8	15.1	165.3	5.5
5 min.	721	62.1	5.2	60.0	309.9	25.8	112.6	9.4
10 min.	485	42.2	7.2	82.4	208.5	35.4	75.8	12.9
15 min.	374	32.5	8.1	93.4	160.6	40.2	58.4	14.6
20 min.	307	26.7	8.8	101.4	132.2	43.6	48.0	15.9
30 min.	230	19.9	9.9	114.7	98.7	49.3	35.9	17.9
45 min.	168	14.4	10.8	126.2	72.4	54.3	26.3	19.7
1 hr.	134	11.5	11.5	134.1	57.7	57.7	21.0	21.0
2 hr.	75	6.4	12.7	150.5	32.4	64.7	11.8	23.5
3 hr.	53	4.4	13.3	159.3	22.8	68.5	8.3	24.9
4 hr.	41	3.4	13.7	164.7	17.7	70.8	6.4	25.7
5 hr.	34	2.8	13.9	168.5	14.5	72.4	5.3	26.3
8 hr.	22	1.8	14.4	176.1	9.5	75.7	3.4	27.5
10 hr.	18	1.5	14.7	179.1	7.7	77.0	2.8	28.0
20 hr.	9	0.8	15.3	188.3	4.0	81.0	1.5	29.4

Figure A-8: XE16 discharge data to 11.1V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2837	283.4	9.4	94.5	768.7	25.6	267.6	8.9
5 min.	1694	160.1	13.3	141.1	459.2	38.2	159.9	13.3
10 min.	1062	95.6	16.3	180.5	287.7	48.9	100.2	17.0
15 min.	793	69.8	17.4	198.2	214.8	53.7	74.8	18.7
20 min.	638	55.6	18.3	210.4	172.8	57.0	60.1	19.8
30 min.	463	39.9	20.0	231.4	125.4	62.7	43.7	21.8
45 min.	333	28.4	21.3	249.7	90.2	67.7	31.4	23.6
1 hr.	262	22.3	22.3	262.1	71.0	71.0	24.7	24.7
2 hr.	144	12.1	24.3	288.7	39.1	78.2	13.6	27.2
3 hr.	101	8.5	25.4	302.3	27.3	81.9	9.5	28.5
4 hr.	78	6.6	26.2	311.8	21.1	84.5	7.4	29.4
5 hr.	64	5.3	26.7	318.6	17.3	86.3	6.0	30.1
8 hr.	41	3.5	27.9	331.1	11.2	89.7	3.9	31.2
10 hr.	34	2.8	28.3	337.5	9.1	91.5	3.2	31.8
20 hr.	18	1.5	30.0	357.1	4.8	96.8	1.7	33.7

Figure A-9: XE30 discharge data to 9V at 25°C

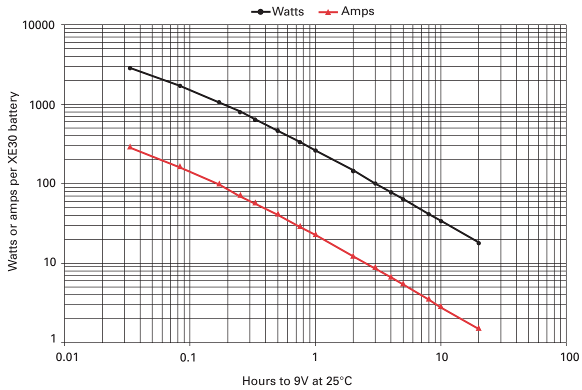
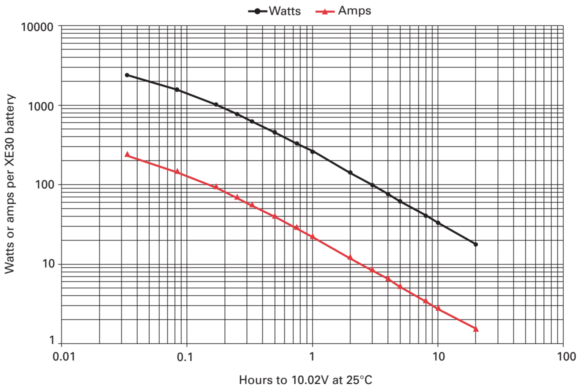
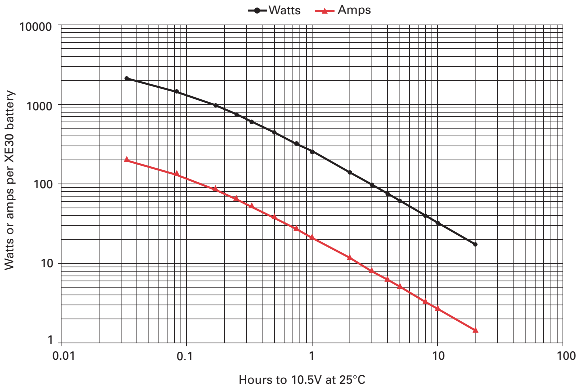


Figure A-10: XE30 discharge data to 10.02V at 25°C



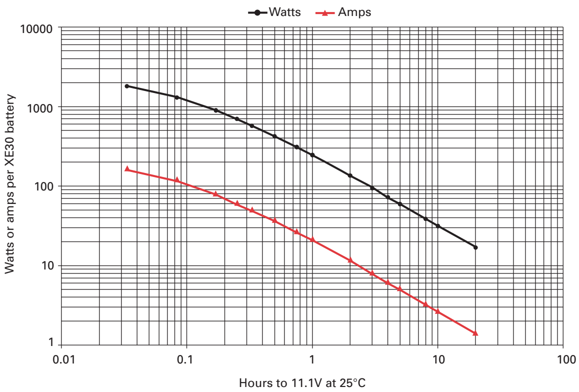
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2381	224.8	7.5	79.3	645.3	21.5	224.7	7.5
5 min.	1565	142.8	11.9	130.3	424.0	35.3	147.6	12.3
10 min.	1017	90.6	15.4	172.9	275.6	46.8	95.9	16.3
15 min.	767	67.4	16.9	191.8	207.9	52.0	72.4	18.1
20 min.	622	54.2	17.9	205.4	168.6	55.7	58.7	19.4
30 min.	455	39.2	19.6	227.6	123.4	61.7	42.9	21.5
45 min.	328	28.1	21.0	245.9	88.9	66.6	30.9	23.2
1 hr.	258	21.9	21.9	258.3	70.0	70.0	24.4	24.4
2 hr.	142	11.9	23.8	283.7	38.4	76.9	13.4	26.8
3 hr.	98	8.3	24.8	294.9	26.6	79.9	9.3	27.8
4 hr.	76	6.4	25.5	304.4	20.6	82.5	7.2	28.7
5 hr.	62	5.2	25.9	309.4	16.8	83.8	5.8	29.2
8 hr.	41	3.4	27.0	323.8	11.0	87.7	3.8	30.5
10 hr.	33	2.75	27.5	330.8	9.0	89.6	3.1	31.2
20 hr.	18	1.5	29.6	354.6	4.8	96.1	1.7	33.5

Figure A-11: XE30 discharge data to 10.5V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2129	195.7	6.5	70.9	576.8	19.2	200.8	6.7
5 min.	1454	130.9	10.9	121.1	391.1	32.8	137.2	11.4
10 min.	972	85.5	14.5	165.3	263.4	44.8	91.7	15.6
15 min.	742	64.5	16.1	185.5	201.1	50.3	70.0	17.5
20 min.	603	52.1	17.2	198.9	163.3	53.9	56.9	18.8
30 min.	444	38.0	19.0	222.0	120.3	60.1	41.9	20.9
45 min.	321	27.3	20.5	240.8	87.0	65.2	30.3	22.7
1 hr.	253	21.4	21.4	252.7	68.5	68.5	23.8	23.8
2 hr.	139	11.7	23.4	278.8	37.8	75.5	13.2	26.3
3 hr.	97	8.1	24.3	291.2	26.3	78.9	9.2	27.5
4 hr.	75	6.2	25.0	299.5	20.3	81.2	7.1	28.3
5 hr.	61	5.1	25.4	306.3	16.6	83.0	5.8	28.9
8 hr.	40	3.3	26.4	317.4	10.8	86.0	3.7	29.9
10 hr.	32	2.7	26.9	324.0	8.8	87.8	3.1	30.6
20 hr.	17	1.4	28.7	347.3	4.7	94.1	1.6	32.8

Figure A-12: XE30 discharge data to 11.1V at 25°C

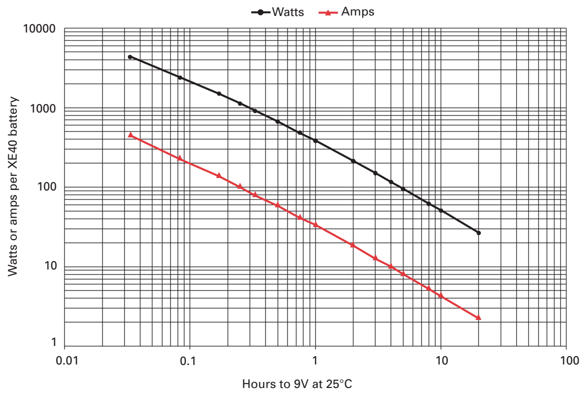


Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1801	160.1	5.3	60.0	487.9	16.2	169.9	5.7
5 min.	1298	113.6	9.5	108.2	351.8	29.3	122.5	10.2
10 min.	895	77.6	13.2	152.2	242.6	41.3	84.5	14.4
15 min.	698	59.6	14.9	174.4	189.0	47.3	65.8	16.5
20 min.	571	48.7	16.1	188.3	154.6	51.0	53.8	17.8
30 min.	425	36.1	18.0	212.2	115.0	57.5	40.0	20.0
45 min.	309	26.1	19.6	231.9	83.8	62.8	29.2	21.9
1 hr.	245	20.6	20.6	244.7	66.3	66.3	23.1	23.1
2 hr.	135	11.3	22.6	270.2	36.6	73.2	12.7	25.5
3 hr.	94	7.9	23.6	282.0	25.5	76.4	8.9	26.6
4 hr.	72	6.1	24.2	289.7	19.6	78.5	6.8	27.3
5 hr.	59	4.9	24.7	296.5	16.1	80.3	5.6	28.0
8 hr.	39	3.2	25.6	308.1	10.4	83.5	3.6	29.1
10 hr.	31	2.6	26.1	314.3	8.5	85.2	3.0	29.6
20 hr.	17	1.4	27.7	336.3	4.6	91.1	1.6	31.7

genesis PURELEAD

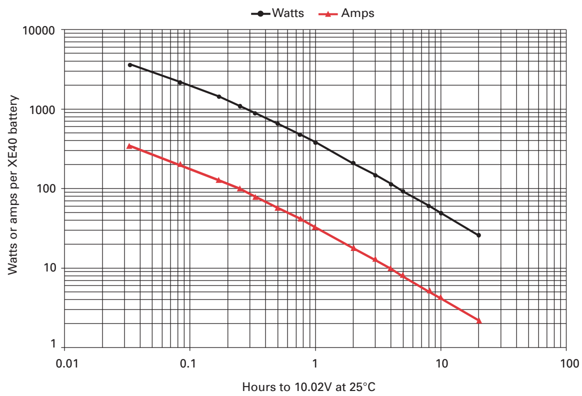
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	4338	436.6	14.5	144.4	777.0	25.9	269.4	9.0
5 min.	2370	226.1	18.8	197.4	424.5	35.4	147.2	12.3
10 min.	1497	136.5	23.2	254.4	268.1	45.6	93.0	15.8
15 min.	1123	100.3	25.1	280.6	201.1	50.3	69.7	17.4
20 min.	909	80.2	26.5	299.9	162.8	53.7	56.5	18.6
30 min.	665	58.0	29.0	332.3	119.1	59.5	41.3	20.6
45 min.	484	41.6	31.2	362.8	86.7	65.0	30.0	22.5
1 hr.	383	32.7	32.7	382.5	68.5	68.5	23.8	23.8
2 hr.	213	18.1	36.2	426.8	38.2	76.5	13.3	26.5
3 hr.	150	12.6	37.8	449.7	26.9	80.6	9.3	27.9
4 hr.	116	9.8	39.1	464.0	20.8	83.1	7.2	28.8
5 hr.	95	8.0	39.9	474.8	17.0	85.0	5.9	29.5
8 hr.	62	5.2	41.6	494.0	11.1	88.5	3.8	30.7
10 hr.	51	4.2	42.4	505.0	9.0	90.5	3.1	31.4
20 hr.	27	2.2	44.4	529.5	4.7	94.8	1.6	32.9

Figure A-13: XE40 discharge data to 9V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	3580	337.9	11.3	119.2	641.2	21.4	222.3	7.4
5 min.	2155	199.1	16.6	179.5	386.1	32.2	133.9	11.2
10 min.	1426	127.9	21.7	242.5	255.5	43.4	88.6	15.1
15 min.	1085	96.0	24.0	271.1	194.3	48.6	67.4	16.8
20 min.	884	77.5	25.6	291.6	158.3	52.2	54.9	18.1
30 min.	652	56.6	28.3	326.0	116.8	58.4	40.5	20.3
45 min.	476	40.8	30.6	356.7	85.2	63.9	29.5	22.2
1 hr.	376	32.1	32.1	376.3	67.4	67.4	23.4	23.4
2 hr.	209	17.7	35.4	418.2	37.5	74.9	13.0	26.0
3 hr.	146	12.3	36.9	438.7	26.2	78.6	9.1	27.2
4 hr.	113	9.5	37.9	451.8	20.2	80.9	7.0	28.1
5 hr.	93	7.7	38.6	462.5	16.6	82.9	5.7	28.7
8 hr.	60	5.0	40.1	481.8	10.8	86.3	3.7	29.9
10 hr.	49	4.1	40.8	490.3	8.8	87.8	3.0	30.5
20 hr.	26	2.2	43.0	518.5	4.6	92.9	1.6	32.2

Figure A-14: XE40 discharge data to 10.02V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	3232	296.4	9.9	107.6	578.9	19.3	200.7	6.7
5 min.	1987	179.6	15.0	165.5	355.9	29.6	123.4	10.3
10 min.	1350	119.4	20.3	229.4	241.7	41.1	83.8	14.2
15 min.	1010	90.9	22.7	260.0	186.3	46.6	64.6	16.2
20 min.	852	74.1	24.4	281.2	152.6	50.4	52.9	17.5
30 min.	633	54.7	27.3	316.6	113.4	56.7	39.3	19.7
45 min.	464	39.7	29.8	347.9	83.1	62.3	28.8	21.6
1 hr.	368	31.3	31.3	368.3	66.0	66.0	22.9	22.9
2 hr.	205	17.3	34.5	410.8	36.8	73.6	12.8	25.5
3 hr.	144	12.1	36.2	431.3	25.8	77.3	8.9	26.8
4 hr.	111	9.3	37.2	444.4	19.9	79.6	6.9	27.6
5 hr.	91	7.6	37.9	453.3	16.2	81.2	5.6	28.2
8 hr.	59	4.9	39.3	473.0	10.6	84.7	3.7	29.4
10 hr.	48	4.0	39.9	481.8	8.6	86.3	3.0	29.9
20 hr.	26	2.1	42.2	509.9	4.6	91.3	1.6	31.7

Figure A-15: XE40 discharge data to 10.5V at 25°C

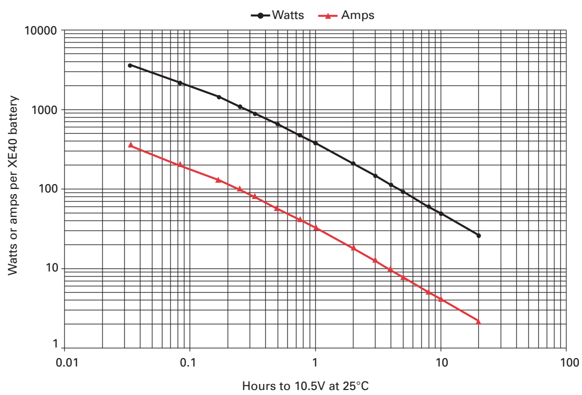
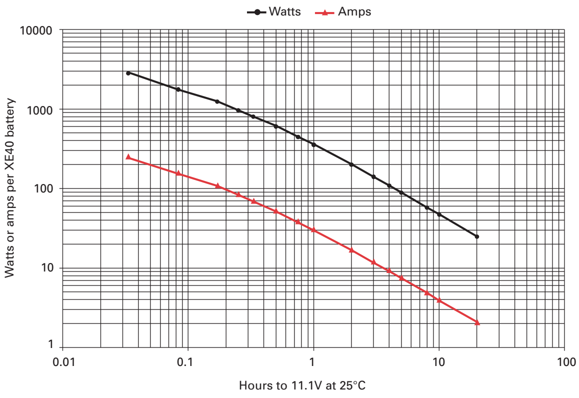
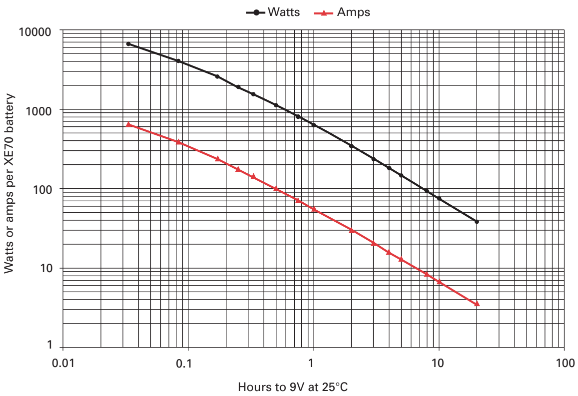


Figure A-16: XE40 discharge data to 11.1V at 25°C



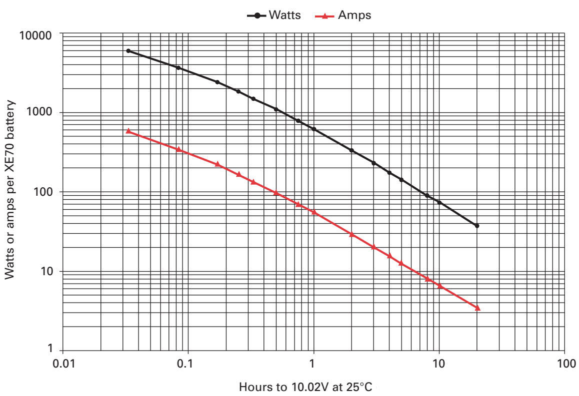
Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2814	249.4	8.3	93.7	504.1	16.8	174.8	5.8
5 min.	1753	153.6	12.8	146.0	314.0	26.2	108.9	9.1
10 min.	1234	106.6	18.1	209.9	221.1	37.6	76.7	13.0
15 min.	964	83.0	20.7	241.0	172.7	43.2	59.9	15.0
20 min.	802	68.5	22.6	264.5	143.6	47.4	49.8	16.4
30 min.	603	51.3	25.7	301.3	107.9	54.0	37.4	18.7
45 min.	445	37.6	28.2	333.8	79.7	59.8	27.6	20.7
1 hr.	355	29.9	29.9	354.6	63.5	63.5	22.0	22.0
2 hr.	200	16.8	33.5	399.7	35.8	71.6	12.4	24.8
3 hr.	140	11.7	35.0	420.2	25.1	75.3	8.7	26.1
4 hr.	109	9.0	36.2	434.6	19.5	77.8	6.7	27.0
5 hr.	89	7.4	36.9	444.1	15.9	79.6	5.5	27.6
8 hr.	58	4.8	38.3	461.2	10.3	82.6	3.6	28.6
10 hr.	47	3.9	38.9	469.6	8.4	84.1	2.9	29.2
20 hr.	25	2.1	41.0	495.2	4.4	88.7	1.5	30.8

Figure A-17: XE70 discharge data to 9V at 25°C



Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	6597	644.0	21.4	219.7	674.0	22.4	256.7	8.5
5 min.	4051	388.4	32.4	337.4	413.9	34.5	157.6	13.1
10 min.	2565	235.6	40.0	436.0	262.0	44.5	99.8	17.0
15 min.	1909	172.3	43.1	477.2	195.0	48.8	74.3	18.6
20 min.	1540	137.8	45.5	508.2	157.3	51.9	59.9	19.8
30 min.	1122	98.5	49.3	561.2	114.7	57.3	43.7	21.8
45 min.	804	70.0	52.5	603.1	82.2	61.6	31.3	23.5
1 hr.	627	54.7	54.6	627.2	64.1	64.1	24.4	24.4
2 hr.	342	29.6	59.2	683.4	34.9	69.8	13.3	26.6
3 hr.	235	20.5	61.4	705.9	24.0	72.1	9.2	27.5
4 hr.	181	15.7	62.6	721.8	18.4	73.7	7.0	28.1
5 hr.	146	12.8	63.8	729.0	14.9	74.5	5.7	28.4
8 hr.	93	8.2	65.7	743.5	9.5	76.0	3.6	28.9
10 hr.	75	6.7	66.6	752.0	7.7	76.8	2.9	29.3
20 hr.	38	3.5	69.3	764.3	3.9	78.1	1.5	29.7

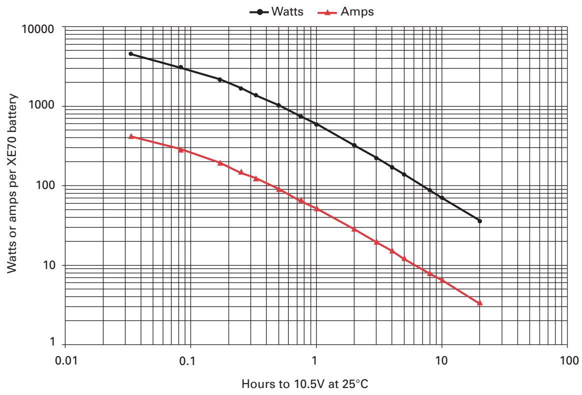
Figure A-18: XE70 discharge data to 10.02V at 25°C



Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	5942	569.8	19.0	197.9	607.0	20.2	231.2	7.7
5 min.	3636	337.6	28.1	302.8	371.4	30.9	141.5	11.8
10 min.	2411	218.5	37.2	409.9	246.3	41.9	93.8	16.0
15 min.	1833	163.8	41.0	458.2	187.2	46.8	71.3	17.8
20 min.	1490	132.6	43.7	491.6	152.2	50.2	58.0	19.1
30 min.	1091	96.0	48.0	545.5	111.5	55.7	42.5	21.2
45 min.	786	68.6	51.4	589.1	80.2	60.2	30.6	22.9
1 hr.	615	53.6	53.6	615.4	62.9	62.9	23.9	23.9
2 hr.	333	28.9	57.8	666.1	34.0	68.1	13.0	25.9
3 hr.	229	19.9	59.6	687.5	23.4	70.2	8.9	26.8
4 hr.	175	15.2	61.0	699.7	17.9	71.5	6.8	27.2
5 hr.	142	12.4	61.8	707.6	14.5	72.3	5.5	27.5
8 hr.	90	8.0	63.6	719.0	9.2	73.5	3.5	28.0
10 hr.	73	6.5	64.5	727.6	7.4	74.3	2.8	28.3
20 hr.	37	3.4	67.9	748.4	3.8	76.5	1.5	29.1

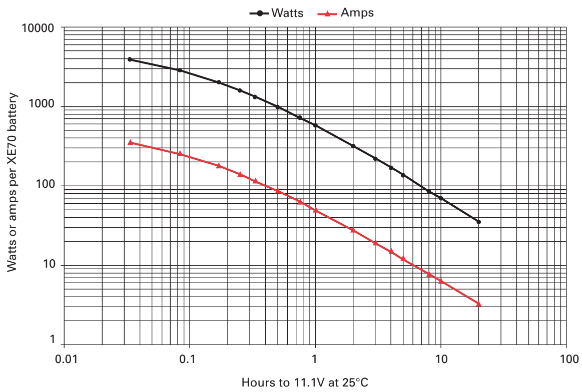
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	5140	480.8	16.0	171.2	525.1	17.5	200.0	6.7
5 min.	3317	301.9	25.1	276.3	338.9	28.2	129.1	10.8
10 min.	2258	201.5	34.3	383.8	230.7	39.2	87.9	14.9
15 min.	1738	154.3	38.6	434.4	177.5	44.4	67.6	16.9
20 min.	1420	125.2	41.3	468.7	145.1	47.9	55.3	18.2
30 min.	1053	92.0	46.0	526.7	107.6	53.8	41.0	20.5
45 min.	761	66.3	49.7	570.4	77.7	58.3	29.6	22.2
1 hr.	600	52.1	52.1	599.9	61.3	61.3	23.3	23.3
2 hr.	327	28.4	56.7	653.8	33.4	66.8	12.7	25.4
3 hr.	225	19.6	58.7	674.6	23.0	68.9	8.7	26.2
4 hr.	172	15.0	60.2	687.5	17.6	70.2	6.7	26.7
5 hr.	139	12.2	60.7	695.3	14.2	71.0	5.4	27.1
8 hr.	89	7.8	62.6	709.2	9.1	72.5	3.4	27.6
10 hr.	72	6.4	63.5	715.3	7.3	73.1	2.8	27.8
20 hr.	37	3.3	66.4	730.0	3.7	74.6	1.4	28.4

Figure A-19: XE70 discharge data to 10.5V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	3911	351.5	11.7	130.2	399.5	13.3	152.2	5.1
5 min.	2870	254.3	21.2	239.0	293.2	24.4	111.7	9.3
10 min.	2028	177.0	30.1	344.7	207.1	35.2	78.9	13.4
15 min.	1586	137.4	34.4	396.4	162.0	40.5	61.7	15.4
20 min.	1313	113.6	37.5	433.3	134.1	44.3	51.1	16.9
30 min.	984	85.2	42.6	492.2	100.6	50.3	38.3	19.2
45 min.	723	62.4	46.8	542.4	73.9	55.4	28.1	21.1
1 hr.	574	49.5	49.5	574.4	58.7	58.7	22.4	22.4
2 hr.	317	27.5	54.9	634.1	32.4	64.8	12.3	24.7
3 hr.	219	19.1	57.1	658.0	22.4	67.2	8.5	25.6
4 hr.	168	14.7	58.9	672.7	17.2	68.7	6.5	26.2
5 hr.	136	12.0	59.7	680.0	13.9	69.5	5.3	26.5
8 hr.	86	7.7	61.4	689.7	8.8	70.5	3.4	26.8
10 hr.	69	6.2	62.2	697.0	7.1	71.2	2.7	27.1
20 hr.	35	3.2	64.4	701.9	3.6	71.7	1.4	27.3

Figure A-20: XE70 discharge data to 11.1V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	8787	903.7	30.1	292.9	696.5	23.2	250.3	8.3
5 min.	5263	491.0	40.9	438.6	417.2	34.8	149.9	12.5
10 min.	3371	304.5	50.8	561.8	267.2	44.5	96.0	16.0
15 min.	2578	228.8	57.2	644.6	204.4	51.1	73.5	18.4
20 min.	2089	183.5	61.2	696.4	165.6	55.2	59.5	19.8
30 min.	1539	133.5	66.8	769.5	122.0	61.0	43.8	21.9
45 min.	1112	95.5	71.6	833.9	88.1	66.1	31.7	23.8
1 hr.	885	75.5	75.5	885.0	70.1	70.1	25.2	25.2
2 hr.	486	41.1	82.2	972.0	38.5	77.0	13.8	27.7
3 hr.	342	28.6	85.8	1026.0	27.1	81.3	9.7	29.2
4 hr.	264	22.3	89.2	1056.0	20.9	83.7	7.5	30.1
5 hr.	216	18.2	91.0	1080.0	17.1	85.6	6.2	30.8
8 hr.	142	12.0	96.0	1132.8	11.2	89.8	4.0	32.3
10 hr.	116	9.8	98.0	1158.0	9.2	91.8	3.3	33.0
20 hr.	63	5.3	106.0	1260.0	5.0	100.0	1.8	35.9

Figure A-21: XE95 discharge data to 9V at 25°C

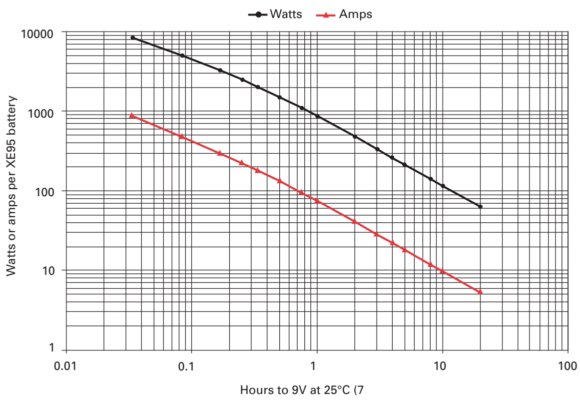
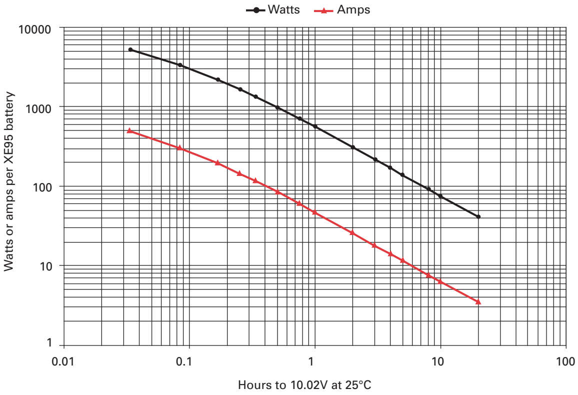
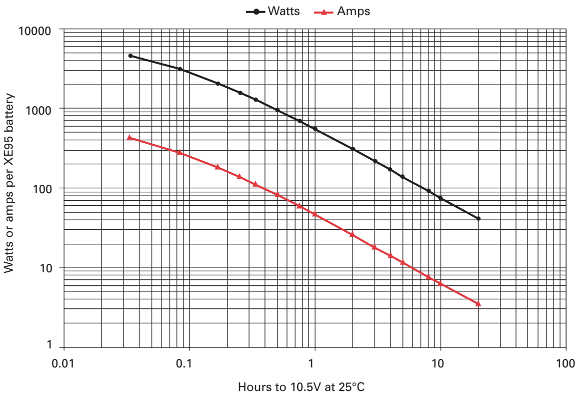


Figure A-22: XE95 discharge data to 10.02V at 25°C



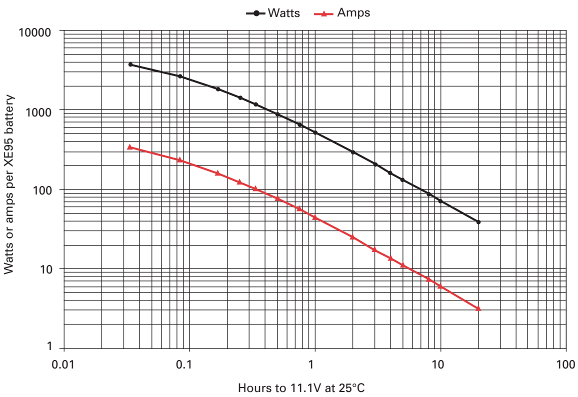
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	7390	707.0	23.6	246.3	585.8	19.5	210.5	7.0
5 min.	4883	449.5	37.5	407.0	387.1	32.3	139.1	11.6
10 min.	3242	290.7	48.5	540.3	257.0	42.8	92.4	15.4
15 min.	2482	219.5	54.9	620.4	196.7	49.2	70.7	17.7
20 min.	2020	177.0	59.0	673.2	160.1	53.4	57.5	19.2
30 min.	1494	129.5	64.8	747.0	118.4	59.2	42.6	21.3
45 min.	1082	92.8	69.6	811.4	85.7	64.3	30.8	23.1
1 hr.	862	73.5	73.5	861.6	68.3	68.3	24.5	24.5
2 hr.	478	40.2	80.4	955.2	37.9	75.7	13.6	27.2
3 hr.	335	28.1	84.3	1004.4	26.5	79.6	9.5	28.6
4 hr.	260	21.8	87.2	1039.2	20.6	82.4	7.4	29.6
5 hr.	212	17.8	89.0	1062.0	16.8	84.2	6.1	30.3
8 hr.	140	11.7	93.6	1118.4	11.1	88.7	4.0	31.9
10 hr.	114	9.6	96.0	1140.0	9.0	90.4	3.2	32.5
20 hr.	61	5.2	104.0	1224.0	4.9	97.0	1.7	34.9

Figure A-23: XE95 discharge data to 10.5V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	6300	585.0	19.5	210.0	499.4	16.6	179.5	6.0
5 min.	4427	399.9	33.3	368.9	350.9	29.2	126.1	10.5
10 min.	3036	268.9	44.8	506.0	240.7	40.1	86.5	14.4
15 min.	2358	206.6	51.7	589.5	186.9	46.7	67.2	16.8
20 min.	1935	168.3	56.1	645.0	153.4	51.1	55.1	18.4
30 min.	1445	124.5	62.3	722.7	114.6	57.3	41.2	20.6
45 min.	1054	90.0	57.5	790.2	83.5	62.6	30.0	22.5
1 hr.	842	81.6	71.6	842.4	66.8	66.8	24.0	24.0
2 hr.	469	39.4	78.8	938.4	37.2	74.4	13.4	26.7
3 hr.	329	27.6	82.8	988.2	26.1	78.3	9.4	28.2
4 hr.	256	21.4	85.6	1022.4	20.3	81.0	7.3	29.1
5 hr.	209	17.5	87.5	1047.0	16.6	83.0	6.0	29.8
8 hr.	137	11.5	92.0	1099.2	10.9	87.1	3.9	31.3
10 hr.	112	9.4	94.0	1122.0	8.9	88.9	3.2	32.0
20 hr.	61	5.1	102.0	1212.0	4.8	96.1	1.7	34.5

Figure A-24: XE95 discharge data to 11.1V at 25°C

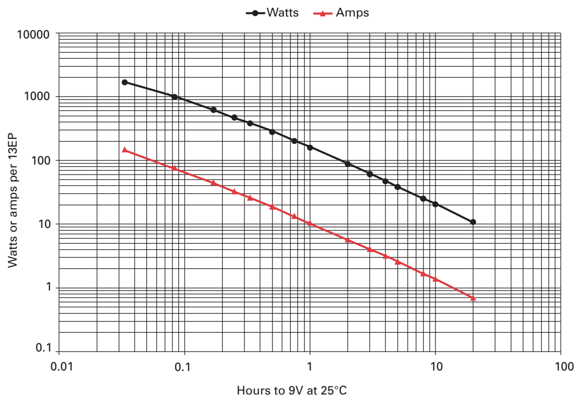


Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	4810	431.9	14.4	160.3	381.3	12.7	137.0	4.6
5 min.	3681	323.1	26.9	306.8	291.8	24.3	104.9	8.7
10 min.	2656	229.8	38.3	442.7	210.5	35.1	75.7	12.6
15 min.	2115	181.6	45.4	528.8	167.6	41.9	60.3	15.1
20 min.	1762	150.6	50.2	587.4	139.7	46.6	50.2	16.7
30 min.	1341	113.9	57.0	670.5	106.3	53.1	38.2	19.1
45 min.	993	83.9	62.9	744.8	78.7	59.0	28.3	21.2
1 hr.	801	67.5	67.5	801.0	63.5	63.5	22.8	22.8
2 hr.	453	37.9	75.8	906.0	35.9	71.8	12.9	25.8
3 hr.	320	26.7	80.1	959.4	25.3	76.0	9.1	27.3
4 hr.	248	20.8	83.2	993.6	19.7	78.8	7.1	28.3
5 hr.	203	17.0	85.0	1017.0	16.1	80.6	5.8	29.0
8 hr.	133	11.1	88.8	1065.6	10.6	84.5	3.8	30.4
10 hr.	109	9.1	91.0	1086.0	8.6	86.1	3.1	30.9
20 hr.	58	4.8	96.0	1164.0	4.6	92.3	1.7	33.2

Appendix B - Genesis® EP Discharge Rates

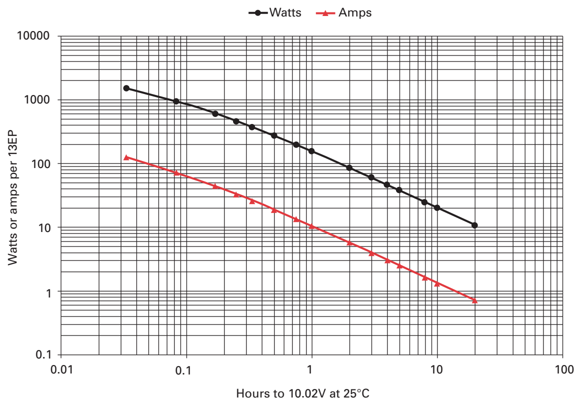
Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1437	149.6	5.0	47.9	756.2	25.2	293.3	9.8
5 min.	791	76.7	6.4	65.9	416.3	34.7	161.4	13.4
10 min.	488	45.3	7.7	83.0	256.8	43.7	99.6	16.9
15 min.	364	33.0	8.3	91.0	191.6	47.9	74.3	18.6
20 min.	293	26.2	8.7	97.6	154.2	51.3	59.8	19.9
30 min.	215	18.9	9.5	107.5	113.1	56.6	43.9	21.9
45 min.	156	13.5	10.1	117.0	82.1	61.6	31.8	23.9
1 hr.	124	10.6	10.6	124.0	65.3	65.3	25.3	25.3
2 hr.	69	5.8	11.6	138.0	36.3	72.6	14.1	28.2
3 hr.	49	4.1	12.3	147.0	25.8	77.4	10.0	30.0
4 hr.	38	3.2	12.8	152.0	20.0	80.0	7.8	31.0
5 hr.	31	2.6	13.0	155.0	16.3	81.6	6.3	31.6
8 hr.	20	1.7	13.6	160.0	10.5	84.2	4.1	32.7
10 hr.	16	1.4	14.0	160.0	8.4	84.2	3.3	32.7
20 hr.	8	0.7	14.0	160.0	4.2	84.2	1.6	32.7

Figure B-1: 13EP discharge data to 9V at 25°C



Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1268.0	123.9	4.1	42.2	667.3	22.2	258.8	8.6
5 min.	758.0	70.8	5.9	63.1	398.9	33.2	154.7	12.9
10 min.	482.0	43.6	7.4	81.9	253.7	43.1	98.4	16.7
15 min.	361.0	32.2	8.1	90.3	190.0	47.5	73.7	18.4
20 min.	292.0	25.7	8.6	97.2	153.7	51.2	59.6	19.8
30 min.	214.0	18.6	9.3	107.0	112.6	56.3	43.7	21.8
45 min.	154.0	13.2	9.9	115.5	81.0	60.8	31.4	23.6
1 hr.	121.0	10.4	10.4	121.0	63.7	63.7	24.7	24.7
2 hr.	67.0	5.7	11.4	134.0	35.3	70.5	13.7	27.3
3 hr.	47.0	3.9	11.7	141.0	24.7	74.2	9.6	28.8
4 hr.	36.0	3.0	12.0	144.0	18.9	75.8	7.3	29.4
5 hr.	29.0	2.5	12.5	145.0	15.3	76.3	5.9	29.6
8 hr.	19.0	1.6	12.8	152.0	10.0	80.0	3.9	31.0
10 hr.	16.0	1.3	13.0	160.0	8.4	84.2	3.3	32.7
20 hr.	8.0	0.7	14.0	160.0	4.2	84.2	1.6	32.7

Figure B-2: 13EP discharge data to 10.02V at 25°C



Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1153.0	108.6	3.6	38.4	606.8	20.2	235.3	7.8
5 min.	715.0	65.5	5.5	59.6	376.3	31.3	145.9	12.2
10 min.	463.0	41.4	7.0	78.7	243.7	41.4	94.5	16.1
15 min.	349.0	30.9	7.7	87.3	183.7	45.9	71.2	17.8
20 min.	283.0	24.8	8.3	94.2	148.9	49.6	57.8	19.2
30 min.	208.0	18.0	9.0	104.0	109.5	54.7	42.4	21.2
45 min.	151.0	12.9	9.7	113.3	79.5	59.6	30.8	23.1
1 hr.	119.0	10.1	10.1	119.0	62.6	62.6	24.3	24.3
2 hr.	66.0	5.5	11.0	132.0	34.7	69.5	13.5	26.9
3 hr.	46.0	3.8	11.4	138.0	24.2	72.6	9.4	28.2
4 hr.	36.0	3.0	12.0	144.0	18.9	75.8	7.3	29.4
5 hr.	29.0	2.4	12.0	145.0	15.3	76.3	5.9	29.6
8 hr.	19.0	1.6	12.8	152.0	10.0	80.0	3.9	31.0
10 hr.	16.0	1.3	13.0	160.0	8.4	84.2	3.3	32.7
20 hr.	8.0	0.7	14.0	160.0	4.2	84.2	1.6	32.7

Figure B-3: 13EP discharge data to 10.5V at 25°C

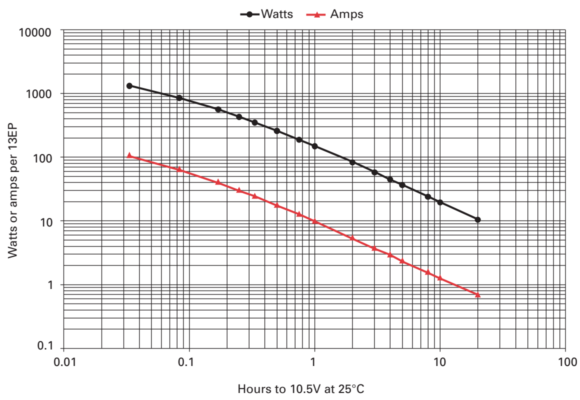
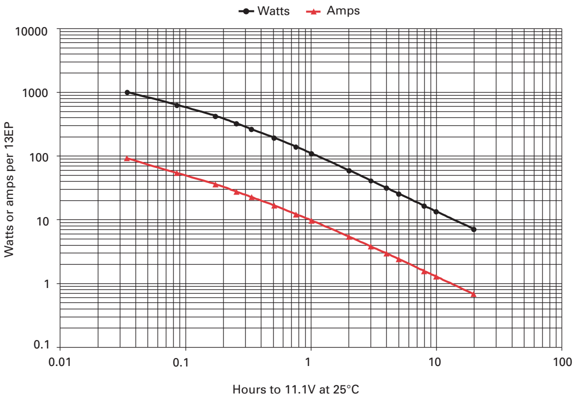
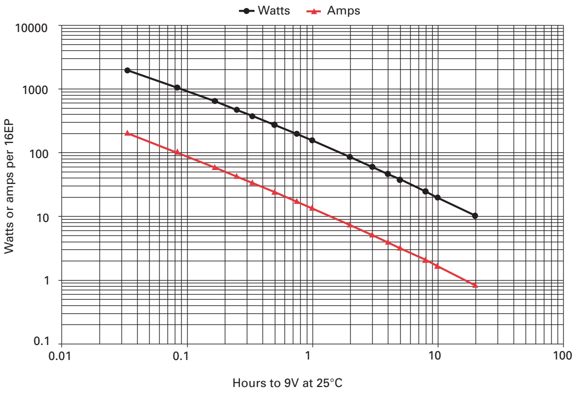


Figure B-4: 13EP discharge data to 11.1V at 25°C



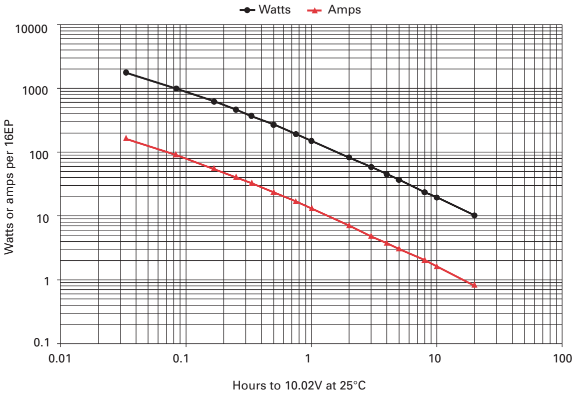
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1001.0	89.2	3.0	33.3	526.8	17.5	204.3	6.8
5 min.	647.0	57.8	4.8	53.9	340.5	28.4	132.0	11.0
10 min.	428.0	37.9	6.4	72.8	225.2	38.3	87.3	14.8
15 min.	328.0	28.8	7.2	82.0	172.6	43.2	66.9	16.7
20 min.	268.0	23.3	7.8	89.2	141.0	47.0	54.7	18.2
30 min.	199.0	17.1	8.6	99.5	104.7	52.4	40.6	20.3
45 min.	145.0	12.4	9.3	108.8	76.3	57.2	29.6	22.2
1 hr.	115.0	9.7	9.7	115.0	60.5	60.5	23.5	23.5
2 hr.	64.0	5.3	10.6	128.0	33.7	67.4	13.1	26.1
3 hr.	45.0	3.7	11.1	135.0	23.7	71.0	9.2	27.6
4 hr.	35.0	2.9	11.6	140.0	18.4	73.7	7.1	28.6
5 hr.	29.0	2.3	11.5	145.0	15.3	76.3	5.9	29.6
8 hr.	19.0	1.5	12.0	152.0	10.0	80.0	3.9	31.0
10 hr.	15.0	1.2	12.0	150.0	7.9	78.9	3.1	30.6
20 hr.	8.0	0.7	14.0	160.0	4.2	84.2	1.6	32.7

Figure B-5: 16EP discharge data to 9V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1900	195.7	6.5	63.3	817.0	27.2	311.5	10.4
5 min.	1028	98.4	8.2	85.6	442.0	36.8	168.5	14.0
10 min.	624	57.2	9.5	104.0	268.3	44.7	102.3	17.1
15 min.	460	41.3	10.3	115.0	197.8	49.5	75.4	18.9
20 min.	368	32.7	10.9	122.7	158.2	52.7	60.3	20.1
30 min.	268	23.4	11.7	134.0	115.2	57.6	43.9	22.0
45 min.	192	16.6	12.5	144.0	82.6	61.9	31.5	23.6
1 hr.	151	13.0	13.0	151.0	64.9	64.9	24.8	24.8
2 hr.	83	7.1	14.2	166.0	35.7	71.4	13.6	27.2
3 hr.	58	4.9	14.7	174.0	24.9	74.8	9.5	28.5
4 hr.	45	3.8	15.2	180.0	19.4	77.4	7.4	29.5
5 hr.	37	3.1	15.5	185.0	15.9	79.6	6.1	30.3
8 hr.	24	2.0	16.0	192.0	10.3	82.6	3.9	31.5
10 hr.	19	1.6	16.0	190.0	8.2	81.7	3.1	31.1
20 hr.	10	0.8	16.0	200.0	4.3	86.0	1.6	32.8

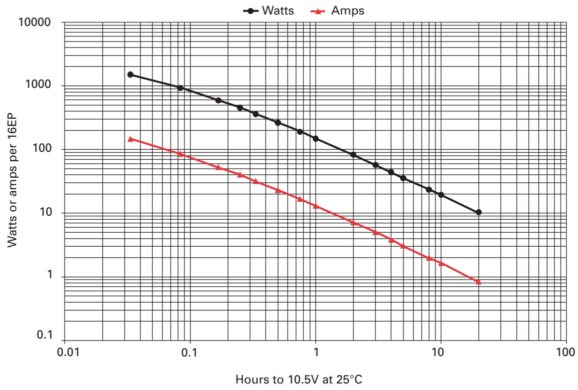
Figure B-6: 16EP discharge data to 10.02V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1674	161.2	5.4	55.7	719.8	24.0	274.4	9.1
5 min.	976	90.0	7.5	81.3	419.7	35.0	160.0	13.3
10 min.	610	54.8	9.1	101.7	262.3	43.7	100.0	16.7
15 min.	454	40.1	10.0	113.5	195.2	48.8	74.4	18.6
20 min.	364	32.0	10.7	121.3	156.5	52.2	59.7	19.9
30 min.	265	23.0	11.5	132.5	114.0	57.0	43.4	21.7
45 min.	190	16.3	12.2	142.5	81.7	61.3	31.1	23.4
1 hr.	149	12.7	12.7	149.0	64.1	64.1	24.4	24.4
2 hr.	82	6.9	13.8	164.0	35.3	70.5	13.4	26.9
3 hr.	57	4.8	14.4	171.0	24.5	73.5	9.3	28.0
4 hr.	44	3.7	14.8	176.0	18.9	75.7	7.2	28.9
5 hr.	36	3.0	15.0	180.0	15.5	77.4	5.9	29.5
8 hr.	23	2.0	16.0	184.0	9.9	79.1	3.8	30.2
10 hr.	19	1.6	16.0	190.0	8.2	81.7	3.1	31.1
20 hr.	10	0.8	16.0	200.0	4.3	86.0	1.6	32.8

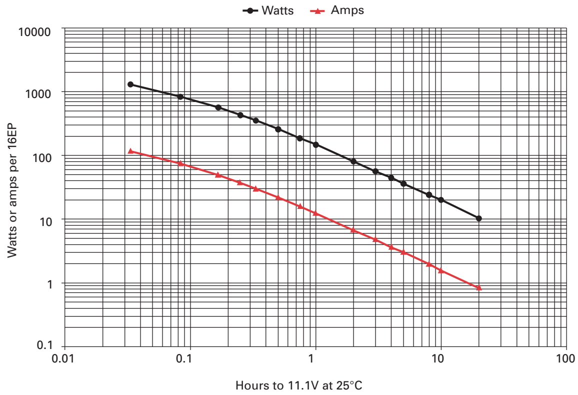
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1502	140.0	4.7	50.0	645.9	21.5	246.2	8.2
5 min.	919	83.0	6.9	76.6	395.2	32.9	150.7	12.5
10 min.	587	52.0	8.7	97.9	252.4	42.1	96.2	16.0
15 min.	441	38.6	9.7	110.3	189.6	47.4	72.3	18.1
20 min.	356	30.9	10.3	118.7	153.1	51.0	58.4	19.5
30 min.	260	22.3	11.2	130.0	111.8	55.9	42.6	21.3
45 min.	187	15.9	11.9	140.3	80.4	60.3	30.7	23.0
1 hr.	147	12.5	12.5	147.0	63.2	63.2	24.1	24.1
2 hr.	81	6.8	13.6	162.0	34.8	69.7	13.3	26.6
3 hr.	56	4.7	14.1	168.0	24.1	72.2	9.2	27.5
4 hr.	43	3.6	14.4	172.0	18.5	74.0	7.0	28.2
5 hr.	35	3.0	15.0	175.0	15.1	75.3	5.7	28.7
8 hr.	23	1.9	15.2	184.0	9.9	79.1	3.8	30.2
10 hr.	19	1.6	16.0	190.0	8.2	81.7	3.1	31.1
20 hr.	10	0.8	16.0	200.0	4.3	86.0	1.6	32.8

Figure B-7: 16EP discharge data to 10.5V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1267	113.2	3.8	42.2	544.8	18.1	207.7	6.9
5 min.	832	72.9	6.1	69.3	357.8	29.8	136.4	11.4
10 min.	551	47.6	7.9	91.9	236.9	39.5	90.3	15.1
15 min.	419	36.0	9.0	104.8	180.2	45.0	68.7	17.2
20 min.	341	29.1	9.7	113.7	146.6	48.9	55.9	18.6
30 min.	251	21.3	10.7	125.5	107.9	54.0	41.1	20.6
45 min.	181	15.3	11.5	135.8	77.8	58.4	29.7	22.3
1 hr.	143	12.0	12.0	143.0	61.5	61.5	23.4	23.4
2 hr.	79	6.6	13.2	158.0	34.0	67.9	13.0	25.9
3 hr.	55	4.6	13.8	165.0	23.7	71.0	9.0	27.0
4 hr.	43	3.5	14.0	172.0	18.5	74.0	7.0	28.2
5 hr.	35	2.9	14.5	175.0	15.1	75.3	5.7	28.7
8 hr.	23	1.9	15.2	184.0	9.9	79.1	3.8	30.2
10 hr.	19	1.5	15.0	190.0	8.2	81.7	3.1	31.1
20 hr.	10	0.8	16.0	200.0	4.3	86.0	1.6	32.8

Figure B-8: 16EP discharge data to 11.1V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2898	302.4	10.1	96.5	785.3	26.2	286.9	9.6
5 min.	1674	162.2	13.5	139.4	453.6	37.8	165.7	13.8
10 min.	1045	96.9	16.2	174.2	283.2	47.2	103.5	17.2
15 min.	778	70.6	17.7	194.5	210.8	52.7	77.0	19.3
20 min.	625	56.0	18.7	208.3	169.4	56.4	61.9	20.6
30 min.	454	40.0	20.0	227.0	123.0	61.5	45.0	22.5
45 min.	326	28.4	21.3	244.5	88.3	66.3	32.3	24.2
1 hr.	256	22.1	22.1	256.0	69.4	69.4	25.3	25.3
2 hr.	140	11.9	23.8	280.0	37.9	75.9	13.9	27.7
3 hr.	97	8.3	24.9	291.0	26.3	78.9	9.6	28.8
4 hr.	75	6.3	25.2	300.0	20.3	81.3	7.4	29.7
5 hr.	61	5.1	25.5	305.0	16.5	82.6	6.0	30.2
8 hr.	39	3.3	26.4	312.0	10.6	84.5	3.9	30.9
10 hr.	32	2.7	27.0	320.0	8.7	86.7	3.2	31.7
20 hr.	16	1.4	28.0	320.0	4.3	86.7	1.6	31.7

Figure B-9: 26EP discharge data to 9V at 25°C

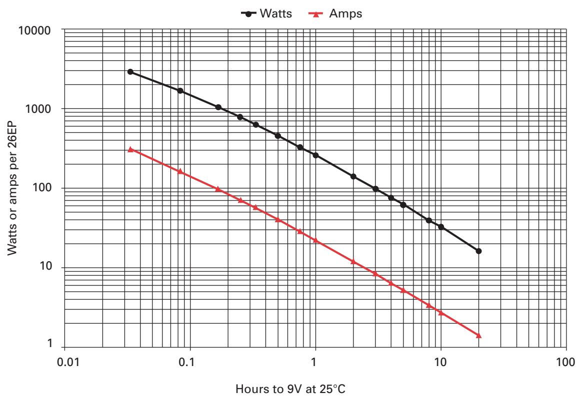
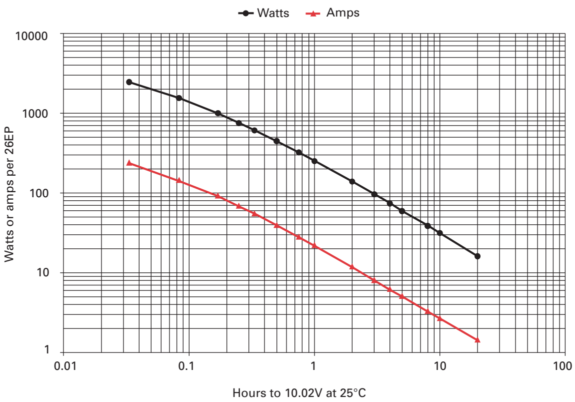
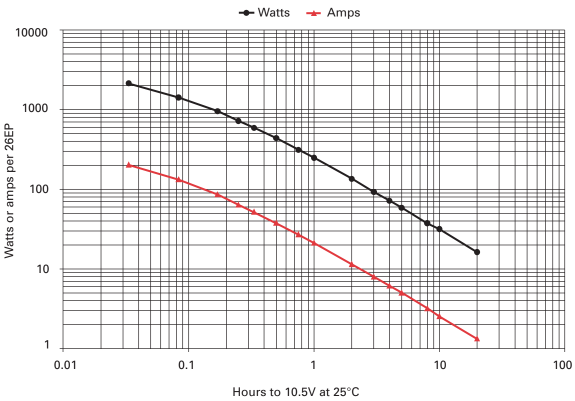


Figure B-10: 26EP discharge data to 10.02V at 25°C



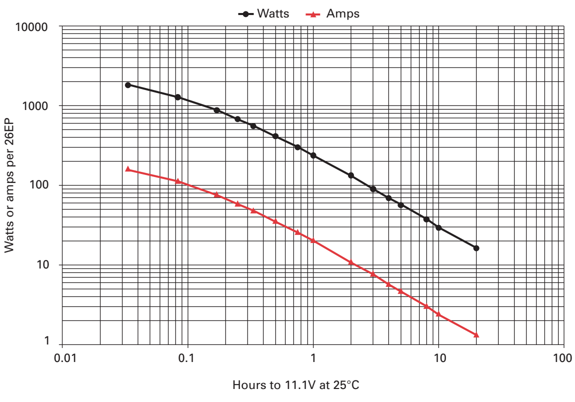
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2419	235.8	7.9	80.6	655.5	21.8	239.5	8.0
5 min.	1532	143.4	11.9	127.6	415.1	34.6	151.7	12.6
10 min.	995	90.7	15.1	165.9	269.6	44.9	98.5	16.4
15 min.	751	67.4	16.9	187.8	203.5	50.9	74.4	18.6
20 min.	607	54.1	18.0	202.3	164.5	54.8	60.1	20.0
30 min.	444	39.0	19.5	222.0	120.3	60.2	44.0	22.0
45 min.	319	27.8	20.9	239.3	86.4	64.8	31.6	23.7
1 hr.	251	21.7	21.7	251.0	68.0	68.0	24.9	24.9
2 hr.	137	11.7	23.4	274.0	37.1	74.2	13.6	27.1
3 hr.	95	8.0	24.0	285.0	25.7	77.2	9.4	28.2
4 hr.	73	6.1	24.4	292.0	19.8	79.1	7.2	28.9
5 hr.	59	5.0	25.0	295.0	16.0	79.9	5.8	29.2
8 hr.	38	3.2	25.6	304.0	10.3	82.4	3.8	30.1
10 hr.	31	2.6	26.0	310.0	8.4	84.0	3.1	30.7
20 hr.	16	1.4	28.0	320.0	4.3	86.7	1.6	31.7

Figure B-11: 26EP discharge data to 10.5V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2141	200.9	6.7	71.3	580.2	19.3	212.0	7.1
5 min.	1424	129.9	10.8	118.6	385.9	32.1	141.0	11.7
10 min.	947	84.7	14.1	157.9	256.6	42.8	93.8	15.6
15 min.	721	63.8	16.0	180.3	195.4	48.8	71.4	17.8
20 min.	587	51.5	17.2	195.6	159.1	53.0	58.1	19.4
30 min.	431	37.5	18.8	215.5	116.8	58.4	42.7	21.3
45 min.	311	26.9	20.2	233.3	84.3	63.2	30.8	23.1
1 hr.	245	21.0	21.0	245.0	66.4	66.4	24.3	24.3
2 hr.	134	11.3	22.6	268.0	36.3	72.6	13.3	26.5
3 hr.	93	7.8	23.4	279.0	25.2	75.6	9.2	27.6
4 hr.	71	6.0	24.0	284.0	19.2	77.0	7.0	28.1
5 hr.	58	4.9	24.5	290.0	15.7	78.6	5.7	28.7
8 hr.	37	3.1	24.8	296.0	10.0	80.2	3.7	29.3
10 hr.	31	2.5	25.0	310.0	8.4	84.0	3.1	30.7
20 hr.	16	1.3	26.0	320.0	4.3	86.7	1.6	31.7

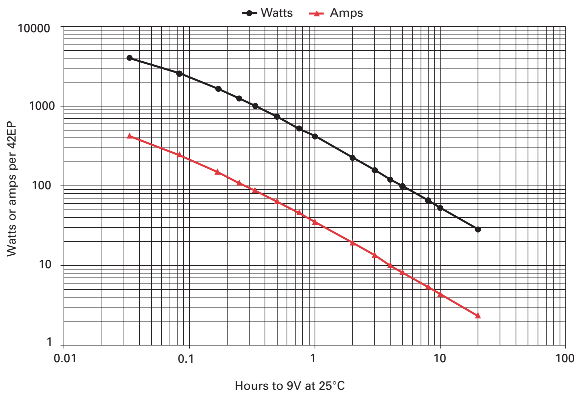
Figure B-12: 26EP discharge data to 11.1V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	1795	159.4	5.3	59.8	486.4	16.2	177.7	5.9
5 min.	1273	111.4	9.3	106.0	345.0	28.7	126.0	10.5
10 min.	876	75.8	12.6	146.0	237.4	39.6	86.7	14.5
15 min.	677	58.2	14.6	169.3	183.5	45.9	67.0	16.8
20 min.	555	47.5	15.8	185.0	150.4	50.1	55.0	18.3
30 min.	412	35.0	17.5	206.0	111.6	55.8	40.8	20.4
45 min.	299	25.3	19.0	224.3	81.0	60.8	29.6	22.2
1 hr.	236	19.9	19.9	236.0	64.0	64.0	23.4	23.4
2 hr.	130	10.8	21.6	260.0	35.2	70.5	12.9	25.7
3 hr.	90	7.5	22.5	270.0	24.4	73.2	8.9	26.7
4 hr.	69	5.7	22.8	276.0	18.7	74.8	6.8	27.3
5 hr.	56	4.7	23.5	280.0	15.2	75.9	5.5	27.7
8 hr.	37	3.0	24.0	296.0	10.0	80.2	3.7	29.3
10 hr.	29	2.4	24.0	290.0	7.9	78.6	2.9	28.7
20 hr.	16	1.3	26.0	320.0	4.3	86.7	1.6	31.7

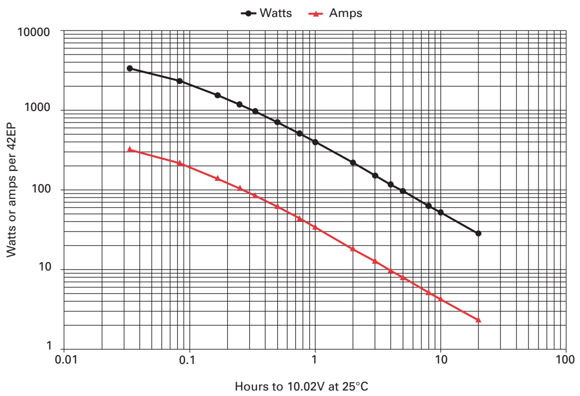
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	4046	417.0	13.9	134.7	724.8	24.1	271.5	9.0
5 min.	2498	240.5	20.0	208.1	447.5	37.3	167.7	14.0
10 min.	1607	148.3	24.7	267.9	287.9	48.0	107.9	18.0
15 min.	1210	109.2	27.3	302.5	216.7	54.2	81.2	20.3
20 min.	979	87.2	29.1	326.3	175.4	58.5	65.7	21.9
30 min.	716	62.7	31.4	358.0	128.3	64.1	48.1	24.0
45 min.	516	44.6	33.5	387.0	92.4	69.3	34.6	26.0
1 hr.	406	34.8	34.8	406.0	72.7	72.7	27.2	27.2
2 hr.	223	18.8	37.6	446.0	39.9	79.9	15.0	29.9
3 hr.	155	13.1	39.3	465.0	27.8	83.3	10.4	31.2
4 hr.	119	10.0	40.0	476.0	21.3	85.3	8.0	31.9
5 hr.	98	8.2	41.0	490.0	17.6	87.8	6.6	32.9
8 hr.	64	5.3	42.4	512.0	11.5	91.7	4.3	34.4
10 hr.	52	4.3	43.0	520.0	9.3	93.1	3.5	34.9
20 hr.	28	2.3	46.0	560.0	5.0	100.3	1.9	37.6

Figure B-13: 42EP discharge data to 9V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	3317	322.3	10.7	110.5	594.2	19.8	222.6	7.4
5 min.	2291	212.0	17.7	190.8	410.4	34.2	153.8	12.8
10 min.	1540	138.4	23.1	256.7	275.9	46.0	103.4	17.2
15 min.	1173	104.1	26.0	293.3	210.1	52.5	78.7	19.7
20 min.	953	83.8	27.9	317.6	170.7	56.9	64.0	21.3
30 min.	698	60.8	30.4	349.0	125.0	62.5	46.8	23.4
45 min.	502	43.3	32.5	376.5	89.9	67.4	33.7	25.3
1 hr.	394	33.8	33.8	394.0	70.6	70.6	26.4	26.4
2 hr.	215	18.2	36.4	430.0	38.5	77.0	14.4	28.9
3 hr.	149	12.6	37.8	447.0	26.7	80.1	10.0	30.0
4 hr.	115	9.7	38.8	460.0	20.6	82.4	7.7	30.9
5 hr.	94	7.9	39.5	470.0	16.8	84.2	6.3	31.5
8 hr.	62	5.1	40.8	496.0	11.1	88.8	4.2	33.3
10 hr.	51	4.2	42.0	510.0	9.1	91.4	3.4	34.2
20 hr.	28	2.3	46.0	560.0	5.0	100.3	1.9	37.6

Figure B-14: 42EP discharge data to 10.02V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2978	279.9	9.3	99.2	533.5	17.8	199.9	6.7
5 min.	2130	193.0	16.1	177.4	381.6	31.8	143.0	11.9
10 min.	1461	129.4	21.6	243.5	261.7	43.6	98.1	16.3
15 min.	1124	98.5	24.6	281.0	201.3	50.3	75.4	18.9
20 min.	919	80.0	26.7	306.3	164.6	54.9	61.7	20.6
30 min.	678	58.5	29.3	339.0	121.5	60.7	45.5	22.8
45 min.	491	42.0	31.5	368.3	88.0	66.0	33.0	24.7
1 hr.	386	32.9	32.9	386.0	69.1	69.1	25.9	25.9
2 hr.	212	17.9	35.8	424.0	38.0	76.0	14.2	28.5
3 hr.	147	12.4	37.2	441.0	26.3	79.0	9.9	29.6
4 hr.	113	9.5	38.0	452.0	20.2	81.0	7.6	30.3
5 hr.	93	7.7	38.5	465.0	16.7	83.3	6.2	31.2
8 hr.	61	5.0	40.0	488.0	10.9	87.4	4.1	32.8
10 hr.	50	4.1	41.0	500.0	9.0	89.6	3.4	33.6
20 hr.	28	2.3	46.0	560.0	5.0	100.3	1.9	37.6

Figure B-15: 42EP discharge data to 10.5V at 25°C

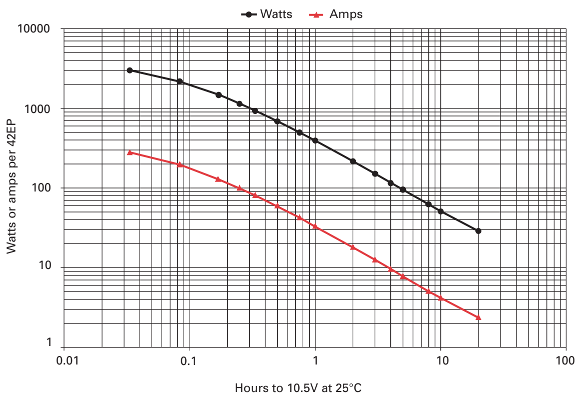
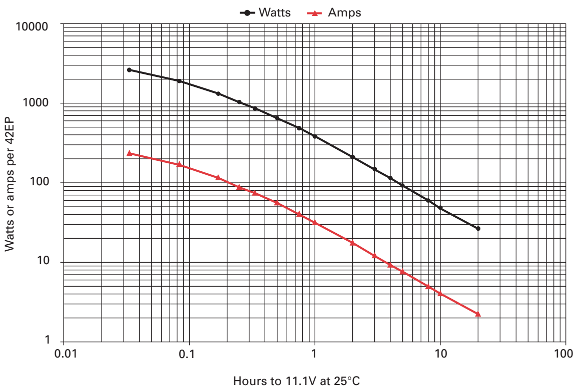
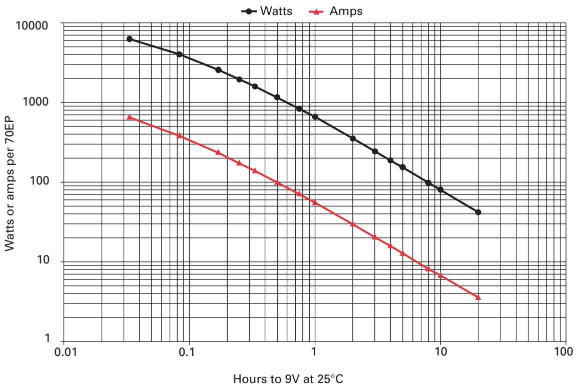


Figure B-16: 42EP discharge data to 11.1V at 25°C



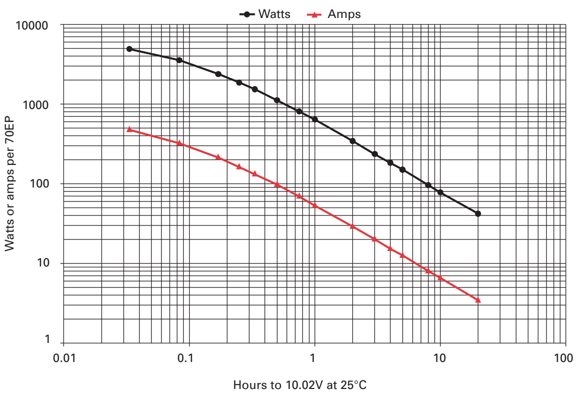
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES W/litre	Wh/litre	W/kg	Wh/kg
2 min.	2581	231.2	7.7	85.9	462.3	15.4	173.2	5.8
5 min.	1901	167.4	13.9	158.4	340.5	28.4	127.6	10.6
10 min.	1338	116.1	19.4	223.0	239.7	40.0	89.8	15.0
15 min.	1046	90.0	22.5	261.5	187.4	46.8	70.2	17.6
20 min.	863	73.9	24.6	287.6	154.6	51.5	57.9	19.3
30 min.	646	54.9	27.5	323.0	115.7	57.9	43.4	21.7
45 min.	473	39.9	29.9	354.8	84.7	63.5	31.7	23.8
1 hr.	376	31.5	31.5	376.0	67.4	67.4	25.2	25.2
2 hr.	208	17.3	34.6	416.0	37.3	74.5	14.0	27.9
3 hr.	145	12.1	36.3	435.0	26.0	77.9	9.7	29.2
4 hr.	112	9.3	37.2	448.0	20.1	80.3	7.5	30.1
5 hr.	91	7.6	38.0	455.0	16.3	81.5	6.1	30.5
8 hr.	59	4.9	39.2	472.0	10.6	84.6	4.0	31.7
10 hr.	48	4.0	40.0	480.0	8.6	86.0	3.2	32.2
20 hr.	26	2.2	44.0	520.0	4.7	93.1	1.7	34.9

Figure B-17: 70EP discharge data to 9V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES W/litre	Wh/litre	W/kg	Wh/kg
2 min.	6186	655.5	21.8	206.0	632.0	21.0	254.6	8.5
5 min.	3924	380.3	31.7	326.9	400.9	33.4	161.5	13.5
10 min.	2552	235.0	39.2	425.4	260.7	43.5	105.0	17.5
15 min.	1926	173.1	43.3	481.5	196.8	49.2	79.3	19.8
20 min.	1560	138.2	46.1	519.9	159.4	53.1	64.2	21.4
30 min.	1143	99.6	49.8	571.5	116.8	58.4	47.0	23.5
45 min.	822	70.7	53.0	616.5	84.0	63.0	33.8	25.4
1 hr.	644	55.0	55.0	644.0	65.8	65.8	26.5	26.5
2 hr.	349	29.5	59.0	698.0	35.7	71.3	14.4	28.7
3 hr.	241	20.3	60.9	723.0	24.6	73.9	9.9	29.8
4 hr.	185	15.6	62.4	740.0	18.9	75.6	7.6	30.5
5 hr.	151	12.6	63.0	755.0	15.4	77.1	6.2	31.1
8 hr.	97	8.1	64.8	776.0	9.9	79.3	4.0	31.9
10 hr.	79	6.6	66.0	790.0	8.1	80.7	3.3	32.5
20 hr.	41	3.5	70.0	820.0	4.2	83.8	1.7	33.7

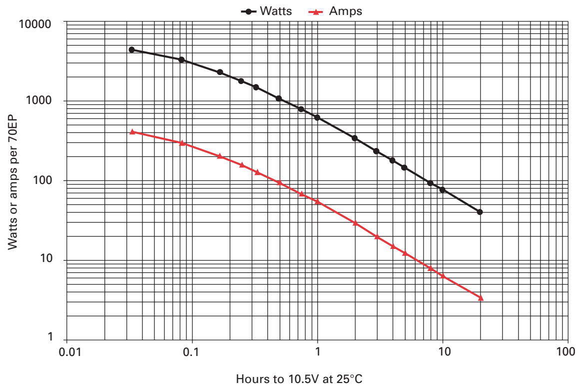
Figure B-18: 70EP discharge data to 10.02V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES W/litre	Wh/litre	W/kg	Wh/kg
2 min.	4938	476.2	15.9	164.4	504.5	16.8	203.2	6.8
5 min.	3525	325.6	27.1	293.6	360.1	30.0	145.1	12.1
10 min.	2416	217.2	36.2	402.7	246.8	41.1	99.4	16.6
15 min.	1858	164.8	41.2	464.5	189.8	47.5	76.5	19.1
20 min.	1517	133.4	44.5	505.6	155.0	51.7	62.4	20.8
30 min.	1118	97.2	48.6	559.0	114.2	57.1	46.0	23.0
45 min.	806	69.5	52.1	604.5	82.3	61.8	33.2	24.9
1 hr.	633	54.2	54.2	633.0	64.7	64.7	26.0	26.0
2 hr.	343	29.1	58.2	686.0	35.0	70.1	14.1	28.2
3 hr.	237	20.0	60.0	711.0	24.2	72.6	9.8	29.3
4 hr.	182	15.2	60.8	728.0	18.6	74.4	7.5	30.0
5 hr.	148	12.4	62.0	740.0	15.1	75.6	6.1	30.5
8 hr.	95	7.9	63.2	760.0	9.7	77.6	3.9	31.3
10 hr.	77	6.5	65.0	770.0	7.9	78.7	3.2	31.7
20 hr.	41	3.4	68.0	820.0	4.2	83.8	1.7	33.7

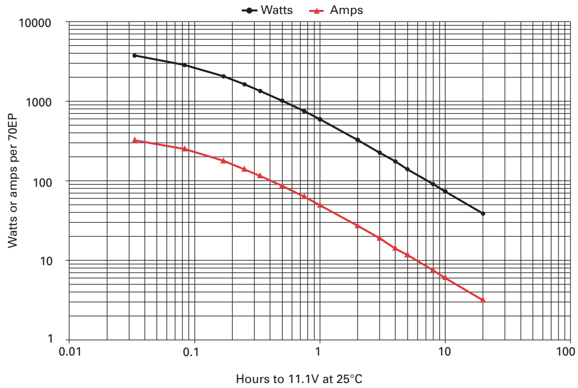
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	4328	404.1	13.5	144.1	442.2	14.7	178.1	5.9
5 min.	3241	293.3	24.4	270.0	331.1	27.6	133.4	11.1
10 min.	2279	202.2	33.7	379.9	232.8	38.8	93.8	15.6
15 min.	1773	155.6	38.9	443.3	181.1	45.3	73.0	18.2
20 min.	1458	127.1	42.4	486.0	149.0	49.6	60.0	20.0
30 min.	1082	93.5	46.8	541.0	110.5	55.3	44.5	22.3
45 min.	785	67.3	50.5	588.8	80.2	60.1	32.3	24.2
1 hr.	619	52.8	52.8	619.0	63.2	63.2	25.5	25.5
2 hr.	337	28.5	57.0	674.0	34.4	68.9	13.9	27.7
3 hr.	233	19.6	58.8	699.0	23.8	71.4	9.6	28.8
4 hr.	179	14.9	59.6	716.0	18.3	73.1	7.4	29.5
5 hr.	145	12.1	60.5	725.0	14.8	74.1	6.0	29.8
8 hr.	94	7.8	62.4	752.0	9.6	76.8	3.9	30.9
10 hr.	76	6.3	63.0	760.0	7.8	77.6	3.1	31.3
20 hr.	40	3.3	66.0	800.0	4.1	81.7	1.6	32.9

Figure B-19: 70EP discharge data to 10.5V at 25°C



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/litre	Wh/litre	W/kg	Wh/kg
2 min.	3791	326.1	10.9	126.2	387.3	12.9	156.0	5.2
5 min.	2846	251.8	21.0	237.1	290.8	24.2	117.1	9.8
10 min.	2071	180.3	30.1	345.2	211.6	35.3	85.2	14.2
15 min.	1638	141.4	35.4	409.5	167.3	41.8	67.4	16.9
20 min.	1361	116.9	39.0	453.6	139.0	46.3	56.0	18.7
30 min.	1024	87.3	43.7	512.0	104.6	52.3	42.1	21.1
45 min.	751	63.6	47.7	563.3	76.7	57.5	30.9	23.2
1 hr.	595	50.2	50.2	595.0	60.8	60.8	24.5	24.5
2 hr.	328	27.4	54.8	656.0	33.5	67.0	13.5	27.0
1 hr.	227	18.9	56.7	681.0	23.2	69.6	9.3	28.0
4 hr.	174	14.5	58.0	696.0	17.8	71.1	7.2	28.6
5 hr.	141	11.8	59.0	705.0	14.4	72.0	5.8	29.0
8 hr.	91	7.5	60.0	728.0	9.3	74.4	3.7	30.0
10 hr.	74	6.1	61.0	740.0	7.6	75.6	3.0	30.5
20 hr.	39	3.2	64.0	780.0	4.0	79.7	1.6	32.1

Figure B-20: 70EP discharge data to 11.1V at 25°C



Notes

Notes

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