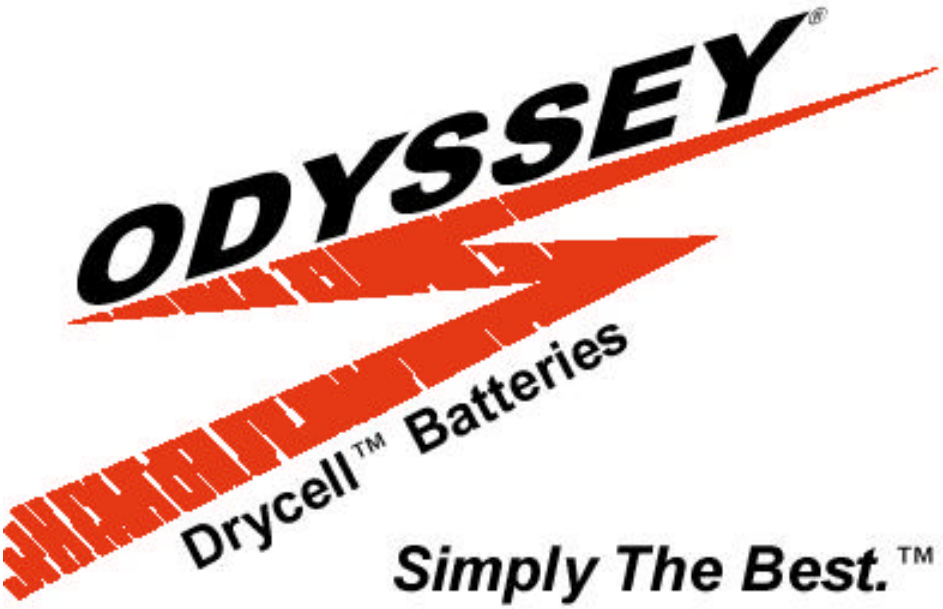

Starting, Lighting & Ignition (SLI) Drycell® battery guide

Fifth Edition Rev1

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Publication ODY–BR–101R

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Preface to the fifth edition

This revision of the ODYSSEY® battery guide has been undertaken for two reasons. The first is the need for an expanded treatment of charging methods. The number and types of chargers available today are truly staggering, and the consumer is justifiably confused about which one is the right type for the ODYSSEY® battery. The hope here is to try and simplify the issue for the consumer so that the battery is not ruined due to inappropriate charging. While it is clearly not possible to cover every type of charger in the market today, I have attempted to provide some general guidelines that should assist the reader to charge the battery correctly.

The second reason for the revision is to discuss ***parasitic loads***, an issue that comes up in an increasing number of applications. As discussed later, unless these loads are accounted for they have the potential to destroy a healthy battery in a matter of, depending on how large the parasitic load is. It is critical for the consumer to be fully aware of what these loads are and how they can have a devastating impact on batteries.

Keep in mind that if parasitic loads are responsible for the premature end of life of an ODYSSEY® battery, it will not be replaced under warranty.

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Introduction

The ODYSSEY® combines in one box the characteristics of two batteries. It can deep cycle as well as provide serious cranking power — it is like a champion long distance runner and a world class sprinter in one body.

These batteries are capable of providing engine cranking pulses of 1700A for 5 seconds as well as 400 charge/discharge cycles to 100% depth of discharge (DOD). A typical battery can do one or the other, but not both. A starting, lighting and ignition (SLI) battery, for example, is designed to provide short, high amperage pulses; it performs poorly when repeatedly taken down to deep depths of discharge. A traditional battery is either like a sprinter or like a long distance runner; ODYSSEY® batteries will do both — provide short duration high amperage pulse or low rate long duration drains.

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Why use ODYSSEY® batteries?

- ***GUARANTEED LONGER SERVICE LIFE*** With a ten year design life and a three-to-eight year service life, ODYSSEY® saves you time and money because you do not have to replace the battery as often. It is the **ONLY** battery capable of delivering a large number of deep cycles — up to 400 when fully discharged or up to 500 when discharged to 80%.

- ***LONGER STORAGE LIFE*** Unlike conventional batteries that need to be recharged every six to twelve weeks the ODYSSEY® battery, when fully charged, can be stored for up to 2 years at 25°C (77°F). At lower temperatures, storage times will be even longer.

- ***DEEP DISCHARGE RECOVERY*** The ease with which ODYSSEY® recovers from such an application abuse is unheard of. The section titled ***Storage and recharge criteria for ODYSSEY® batteries*** discusses actual test data on this important topic concerning SLI batteries.

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- ***SUPERIOR CRANKING AND FAST CHARGE CAPABILITY*** The cranking power of ODYSSEY® batteries is double to triple that of equally sized conventional batteries, even when the temperature is as low as –40°C. Also, with simple constant voltage charging, there is no limitation on the inrush current, so the user is assured of fast charge. This characteristic is explored in greater detail later in the section titled ***Rapid charging of ODYSSEY® batteries.***

- ***WORRY-FREE SHIPPING*** The valve regulated design of the ODYSSEY® battery eliminates the need for vent tubes; further, no routine maintenance is required and there is no more fear of acid burns or damage to expensive chrome or paint. Owing to the starved-electrolyte design, the US Department of Transportation (USDOT) has classified the ODYSSEY® battery as a dry battery, so it may be shipped worry-free by UPS/Federal Express or by air.

- ***MOUNTING FLEXIBILITY*** The ODYSSEY® battery may be installed on its sides without sacrificing any performance attributes**.** There is also no fear of any acid spillage.

- ***SUPERIOR VIBRATION RESISTANCE*** ODYSSEY® batteries have endured rigorous tests that demonstrate their overall ruggedness and exceptional tolerance of mechanical abuse. Details of these tests may be found in the section titled ***Shock, impact and vibration testing***.

- ***READY OUT OF THE BOX*** ODYSSEY® batteries are shipped fully charged. Simply install the battery in your vehicle and you are ready to go! **With this battery, there is no need to boost charge, add water or clean terminals before installing**.

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ODYSSEY® SLI battery specifications

	ODYSSEY® model (Ah @ 10 hr. rate)						
	PC 535 (13Ah)	PC 545 (12Ah)	PC 680 (16Ah)	PC 625 (16Ah)	PC 925 (27Ah)	PC 1200 (40Ah)	PC 1700 (65Ah)
5 sec. hot cranking amps (HCA)	535A	545A	680A	625A	925A	1200A	1700A
CCA	200A	185A	220A	265A	380A	550A	875A
CA @32°F	265A	240A	300A	350A	500A	725A	1175A
HCA @80°F	300A	300A	370A	440A	625A	860A	1325A
Reserve capacity	21 min.	19 min.	25 min.	27 min.	50 min.	78 min.	142 min.
Terminals	Female threaded for M6 stainless steel bolt				SAE automotive with 3/8" top female thread		
Terminal torque, in-lb.	40	50	50	40	60	60	60
Length, in. (mm.)[1]	6.70 (170.2)	7.00 (177.8)	7.27 (184.7)	6.70 (170.2)	6.64 (168.6)	7.87 (199.9)	13.02 (330.7)
Width, in. (mm.)	3.90 (99.1)	3.37 (85.6)	3.11 (79.0)	3.90 (99.1)	7.05 (179.0)	6.66 (169.1)	6.62 (168.2)
Height, in. (mm.)[2]	6.125 (155.6)	5.17 (131.3)	6.67 (169.4)	6.89 (175.0)	5.04 (128.0)	6.80 (172.7)	6.93 (176.0)
Weight, lb. (kg.)[3]	12.0 (5.4)	12.0 (5.4)	14.7 (6.7)	13.2 (6.0)	24.0 (10.9)	35.4 (16.0)	58.7 (26.6)
Cycle life @77°F	400 at 100% DOD and 14.7V charge for 16 to 24 hours 500 at 80% DOD and 14.7V charge for 16 to 24 hours						
Temperature range	- 40°C (- 40°F) to +45°C (113°F) for PC 535 & PC 625 - 40°C (- 40°F) to +80°C (176°F) with metal jacket on all other sizes						
Resistance at 1 kHz @77°F	8mW	10mW	7mW	7mW	5mW	4.5mW	3.5mW
Short ckt. current	> 1,000A	> 1,200A	> 1,800A	> 1,800A	> 2,400A	> 2,600A	> 3,500A

[1] Length dimensions measured on terminal side and include metal jacket, ***except on PC 535 and PC 625***.
[2] Add 0.75" for automotive terminals ***(available ONLY on PC 680, PC 925, PC 1200 and PC 1700)***
[3] PC 535 and PC 625 do not have metal jackets; all other weights include metal jackets

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Pulse discharge capabilities

The graph below demonstrates the extraordinary short duration (pulse) discharge capabilities of the ODYSSEY® family of batteries.

Three points should be kept in mind when using this battery for such extreme high-rate discharges. First, sufficient time must be given between two successive discharges to allow the terminals to cool down. Second, the graph reflects the capabilities of ***fully charged*** ODYSSEY® batteries. Unless they are fully charged, one must not expect them to meet these numbers. Finally, if the temperature is significantly different from 25°C, the graph shown must be appropriately modified.

Table I below provides the five, ten and twenty second pulse discharge numbers for the ODYSSEY® line of Drycell™ batteries.

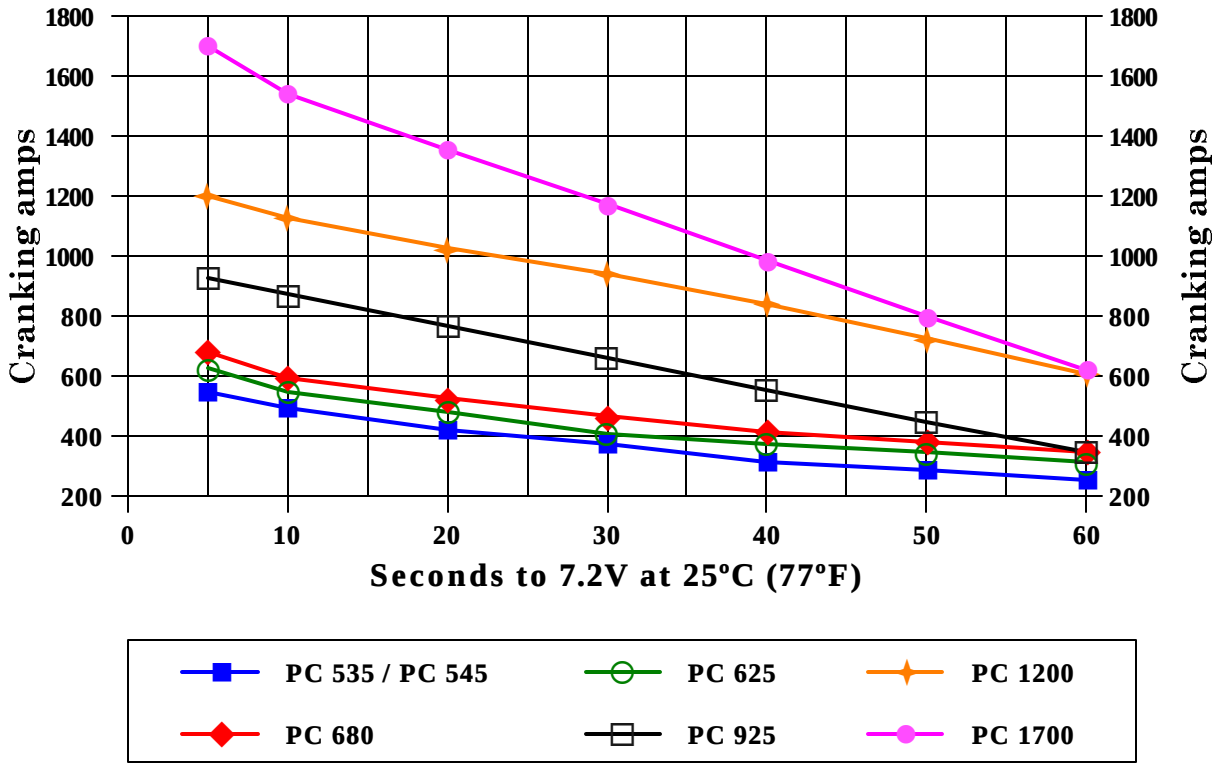

Table I

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Battery	Pulse discharge in amps to 7.2V		
	5 sec.	10 sec.	20 sec.
PC 535	535	465	410
PC 545	545	495	420
PC 680	680	595	525
PC 625	625	545	480
PC 925	925	870	765
PC 1200	1200	1090	900
PC 1700	1700	1540	1355

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Long duration discharge characteristics

In addition to its excellent pulse discharge capabilities, the ODYSSEY® battery is also capable of delivering many deep discharge cycles. This is another area where the ODYSSEY® Drycell™ battery outperforms a conventional SLI battery, which can deliver only a few deep discharge cycles.

The following seven graphs detail the discharge characteristics of the entire ODYSSEY® line. The end of discharge voltage in each case is 10.02V per battery, and each graph shows both constant current (CC) and constant power (CP) curves.

The tables accompanying each graph give the same data as the graph above it, together with the energy and power densities. The battery run times extend from 2 minutes to 20 hours.

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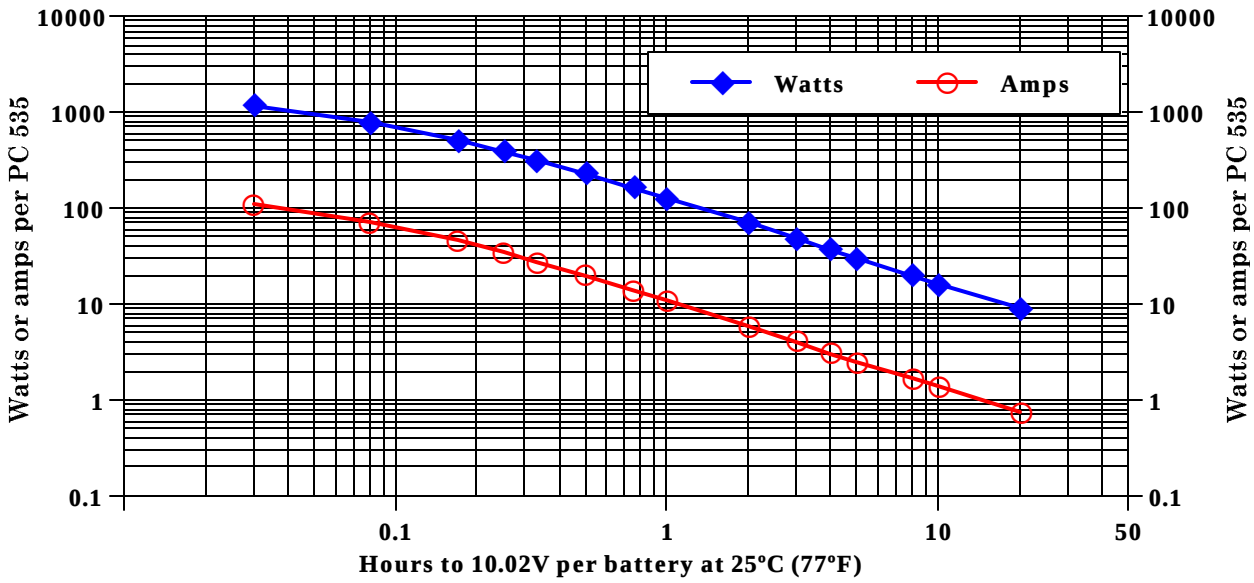

ODYSSEY® PC 535 performance data at 25°C, per 12V module

Time to 10.02V	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	Energy and power densities			
					W/lit.	Wh/lit.	W/kg.	Wh/kg.
2 min	1182	112.0	3.40	35.5	450.7	13.5	218.9	6.6
5 min	786	71.9	5.75	62.9	299.7	24.0	145.6	11.6
10 min	517.2	46.3	7.90	87.9	197.2	33.5	98.8	16.3
15 min	390.6	34.5	8.60	97.65	148.9	37.2	72.3	18.1
20 min	316.2	27.7	9.10	104.35	120.6	39.8	58.6	19.3
30 min	230.4	20.0	10.0	115.2	87.85	43.9	42.7	21.3
45 min	165	14.2	10.65	123.75	62.9	47.2	30.6	22.9
1 hr	129	11.0	11.0	129.0	49.2	49.2	23.9	23.9
2 hr	70.2	5.9	11.8	140.4	26.8	53.5	13.0	26.0
3 hr	48.5	4.1	12.3	145.4	18.5	55.5	9.0	26.9
4 hr	37.3	3.1	12.4	149.3	14.2	56.9	6.9	27.6
5 hr	30.5	2.5	12.5	152.4	11.6	58.1	5.6	28.2
8 hr	19.9	1.7	13.6	159.4	7.6	60.8	3.7	29.5
10 hr	16.3	1.3	13.0	163.2	6.2	62.2	3.0	30.2
20 hr	9	0.74	14.8	178.8	3.4	68.2	1.7	33.1

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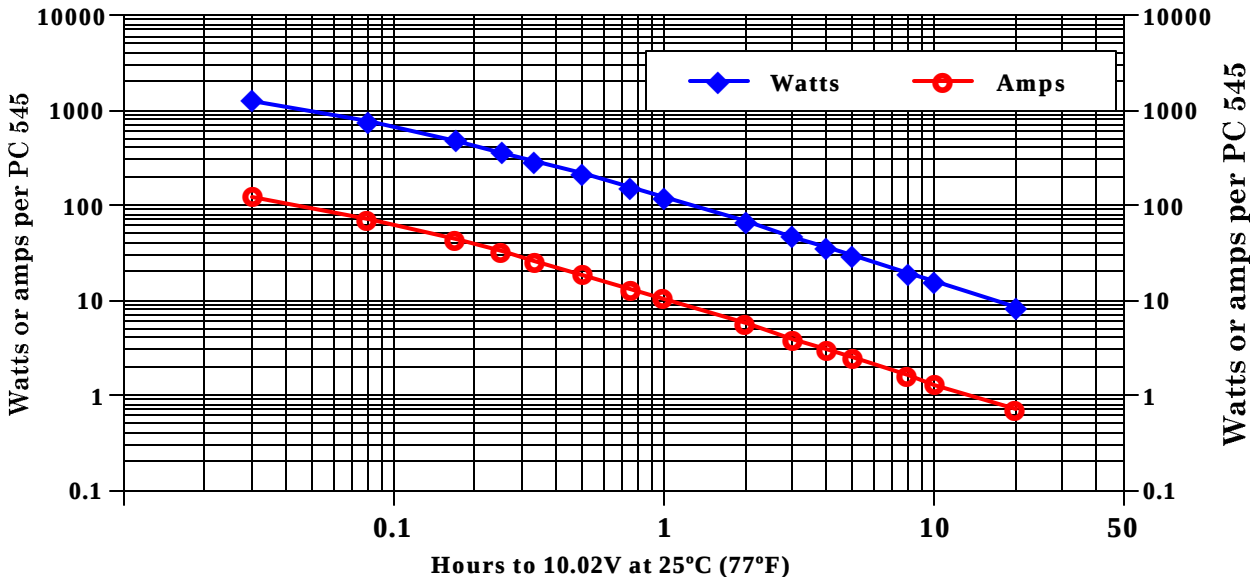

ODYSSEY® PC 545 performance data at 25°C, per 12V module

Time to 10.02V	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	Energy and power densities			
					W/lit.	Wh/lit.	W/kg.	Wh/kg.
2 min	1268	123.9	4.10	42.30	665.20	22.20	264.10	8.80
5 min	758	70.8	5.90	63.20	397.90	33.20	158.00	13.20
10 min	482	43.6	7.30	80.30	252.80	42.10	100.40	16.70
15 min	361	32.2	8.05	90.30	189.50	47.40	75.25	18.80
20 min	292	25.7	8.60	97.20	153.00	51.00	60.75	20.25
30 min	214	18.6	9.30	106.80	112.10	56.00	44.50	22.25
45 min	154	13.2	9.90	115.65	80.90	60.70	32.10	24.10
1 hr	121	10.4	10.40	121.20	63.60	63.60	25.25	25.25
2 hr	67	5.7	11.40	134.40	35.30	70.50	14.00	28.00
3 hr	47	3.9	11.70	140.40	24.60	73.70	9.75	29.25
4 hr	36	3.0	12.00	144.00	18.90	75.55	7.50	30.00
5 hr	29	2.5	12.50	147.00	15.40	77.10	6.10	30.60
8 hr	19	1.6	12.80	153.60	10.10	80.60	4.00	32.00
10 hr	16	1.2	12.00	156.00	8.20	81.85	3.25	32.50
20 hr	8	0.7	14.00	168.00	4.40	88.15	1.75	35.00

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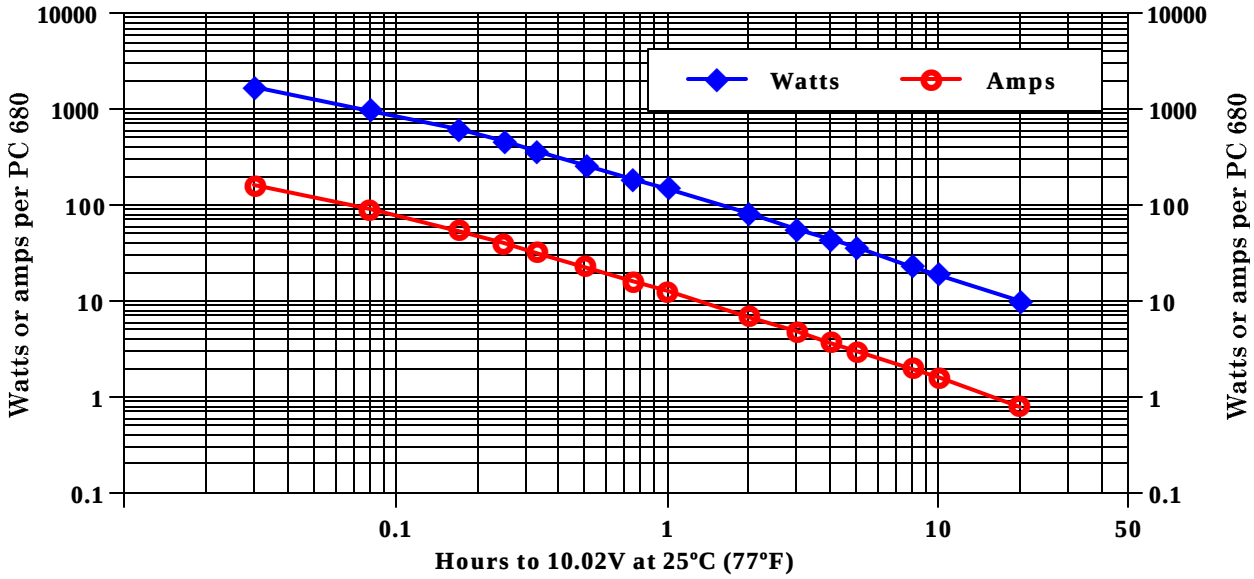

ODYSSEY® PC 680 performance data at 25°C, per 12V module

Time to 10.02V	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	Energy and power densities			
					W/lit.	Wh/lit.	W/kg.	Wh/kg.
2 min	1674	161.2	5.40	55.80	711.25	23.70	270.00	9.00
5 min	976	90.0	7.50	81.30	414.50	34.50	157.35	13.10
10 min	610	54.8	9.10	101.60	259.00	43.20	98.30	16.40
15 min	454	40.1	10.00	113.40	192.70	48.20	73.20	18.30
20 min	364	32.0	10.70	121.40	154.70	51.60	58.70	19.60
30 min	265	23.0	11.50	132.30	112.40	56.20	42.70	21.30
45 min	190	16.3	12.20	142.65	80.80	60.60	30.70	23.00
1 hr	149	12.7	12.70	149.40	63.50	63.50	24.10	24.10
2 hr	82	6.9	13.80	164.40	34.90	69.85	13.30	26.50
3 hr	57	4.8	14.40	171.00	24.20	72.65	9.20	27.60
4 hr	44	3.7	14.80	177.60	18.90	75.50	7.10	28.65
5 hr	36	3.0	15.00	180.00	15.30	76.50	5.80	29.00
8 hr	23	2.0	16.00	187.20	9.90	79.50	3.80	30.20
10 hr	19	1.6	16.00	192.00	8.20	81.60	3.10	31.00
20 hr	10	0.8	16.00	204.00	4.30	86.70	1.65	32.90

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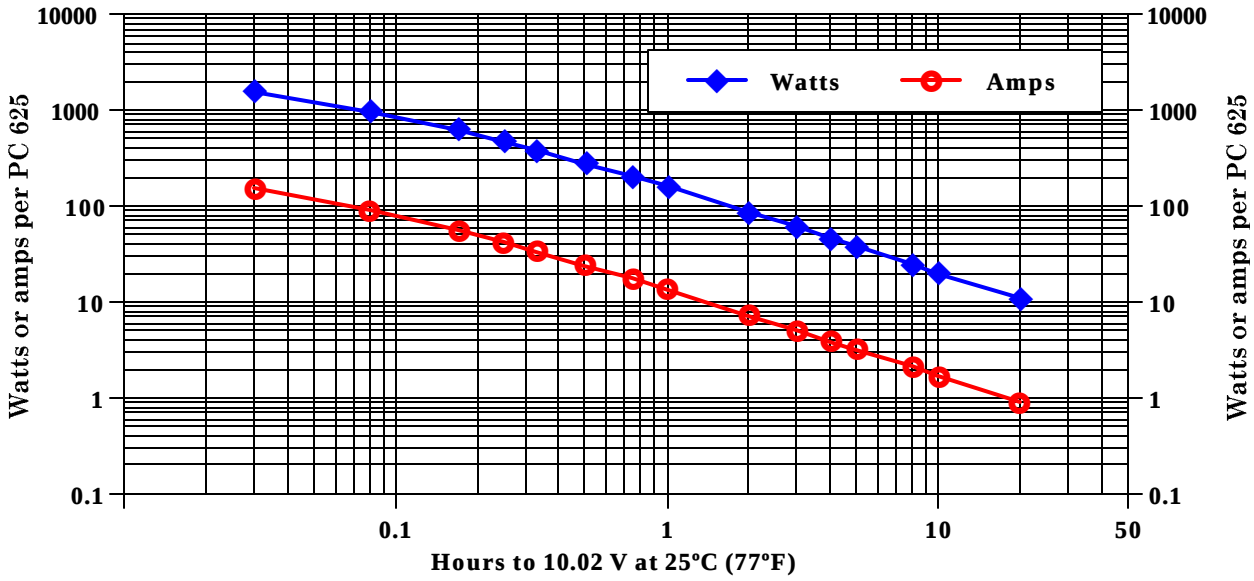

ODYSSEY® PC 625 performance data at 25°C, per 12V module

Time to 10.02V	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	Energy and power densities			
					W/lit.	Wh/lit.	W/kg.	Wh/kg.
2 min	1582	154.7	5.20	52.70	536.10	17.90	255.10	8.50
5 min	986	91.6	7.60	82.20	334.35	27.90	159.10	13.30
10 min	635	57.1	9.50	105.90	215.40	35.90	102.50	17.10
15 min	478	42.3	10.60	119.40	161.90	40.50	77.0	19.30
20 min	385	33.8	11.30	128.40	130.60	43.50	62.10	20.70
30 min	281	24.4	12.20	140.70	95.40	47.70	45.40	22.70
45 min	202	17.4	13.05	151.65	68.50	51.40	32.60	24.50
1 hr	159	13.6	13.60	159.0	53.90	53.90	25.65	25.65
2 hr	87	7.3	14.60	174.0	29.50	59.0	14.0	28.10
3 hr	61	5.1	15.30	181.80	20.50	61.60	9.80	29.30
4 hr	47	3.9	15.60	187.20	15.90	63.45	7.55	30.20
5 hr	38	3.2	16.0	192.0	13.0	65.10	6.20	31.0
8 hr	25	2.1	16.80	201.60	8.50	68.30	4.10	32.50
10 hr	20	1.7	17.0	204.0	6.90	69.15	3.30	32.90
20 hr	11	0.9	18.0	216.0	3.70	73.20	1.70	34.80

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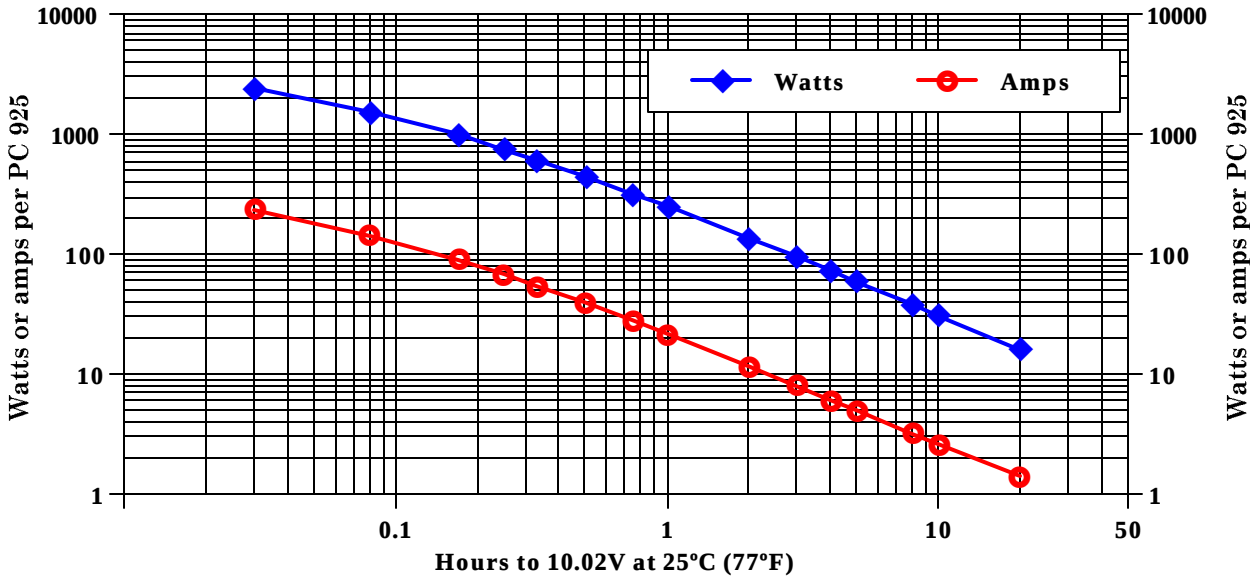

ODYSSEY® PC 925 performance data at 25°C, per 12V module

Time to 10.02V	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	Energy and power densities			
					W/lit.	Wh/lit.	W/kg.	Wh/kg.
2 min	2419	235.8	7.90	80.60	654.50	21.80	228.20	7.60
5 min	1532	143.4	11.95	127.65	414.50	34.50	144.50	12.0
10 min	995	90.7	15.10	165.90	269.40	44.90	93.90	15.65
15 min	751	67.4	16.85	187.65	203.10	50.80	70.80	17.70
20 min	607	54.1	18.0	202.40	164.30	54.80	57.30	19.10
30 min	444	39.0	19.50	222.0	120.15	60.10	41.90	20.90
45 min	319	27.8	20.85	239.40	86.40	64.80	30.10	22.60
1 hr	251	21.7	21.70	250.80	67.90	67.90	23.70	23.70
2 hr	137	11.7	23.40	273.60	37.0	74.0	12.90	25.80
3 hr	95	8.0	24.0	284.40	25.65	77.0	8.90	26.80
4 hr	73	6.1	24.0	290.40	19.65	78.60	6.85	27.40
5 hr	59	5.0	25.0	297.0	16.10	80.40	5.60	28.0
8 hr	38	3.2	25.60	307.20	10.40	83.10	3.60	29.0
10 hr	31	2.7	27.0	312.0	8.40	84.40	2.90	29.40
20 hr	16	1.4	28.0	324.0	4.40	87.70	1.50	30.60

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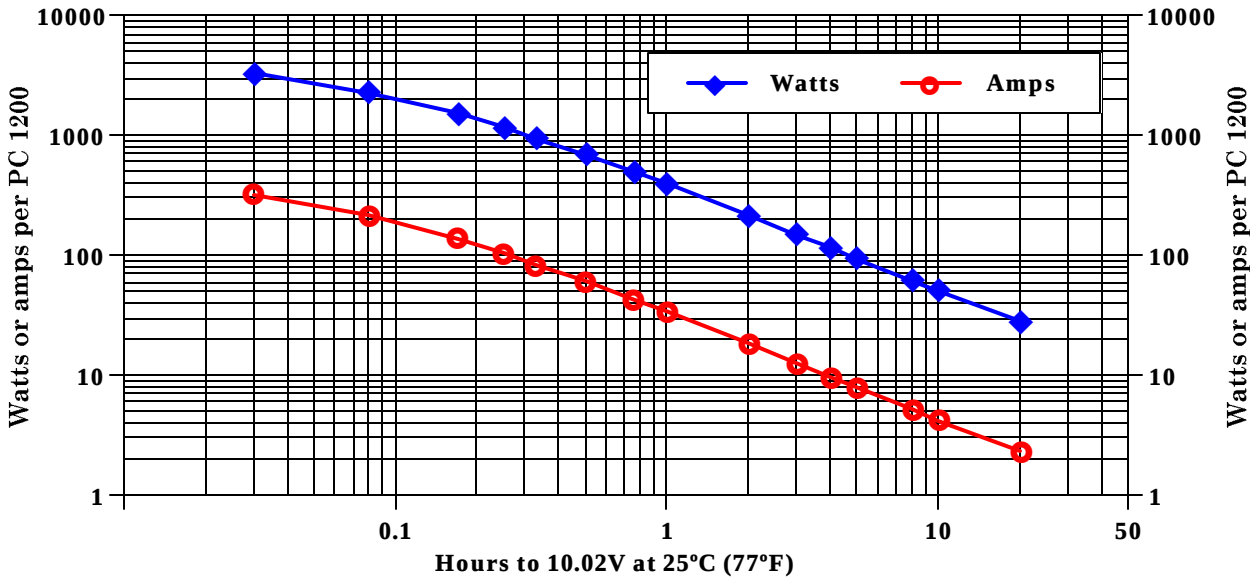

ODYSSEY® PC 1200 performance data at 25°C, per 12V module

Time to 10.02V	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	Energy and power densities			
					W/lit.	Wh/lit.	W/kg.	Wh/kg.
2 min	2872	302.5	10.10	110.60	593.0	19.80	225.70	7.50
5 min	2154	199.0	16.58	190.95	409.60	34.10	155.90	13.0
10 min	1422	128.0	21.33	256.6	275.20	45.90	104.70	17.50
15 min	1086	96.0	24.00	293.25	209.70	52.40	79.80	19.95
20 min	882	77.6	25.87	317.6	170.30	56.80	64.80	21.60
30 min	654	56.7	28.35	348.9	124.70	62.40	47.50	23.70
45 min	476	40.9	30.68	376.65	89.80	67.30	34.20	25.60
1 hr	376	32.1	32.10	393.6	70.35	70.35	26.80	26.80
2 hr	209	17.6	35.20	429.6	38.40	76.80	14.60	29.20
3 hr	146	12.3	36.90	448.2	26.70	80.10	10.20	30.50
4 hr	113	9.5	38.00	460.8	20.60	82.40	7.80	31.35
5 hr	92	7.7	38.50	471.0	16.80	84.20	6.40	32.0
8 hr	60	5.0	40.00	494.4	11.05	88.40	4.20	33.60
10 hr	49	4.1	41.00	510.0	9.10	91.20	3.50	34.70
20 hr	26	2.2	44.00	564.0	5.0	100.80	1.90	38.40

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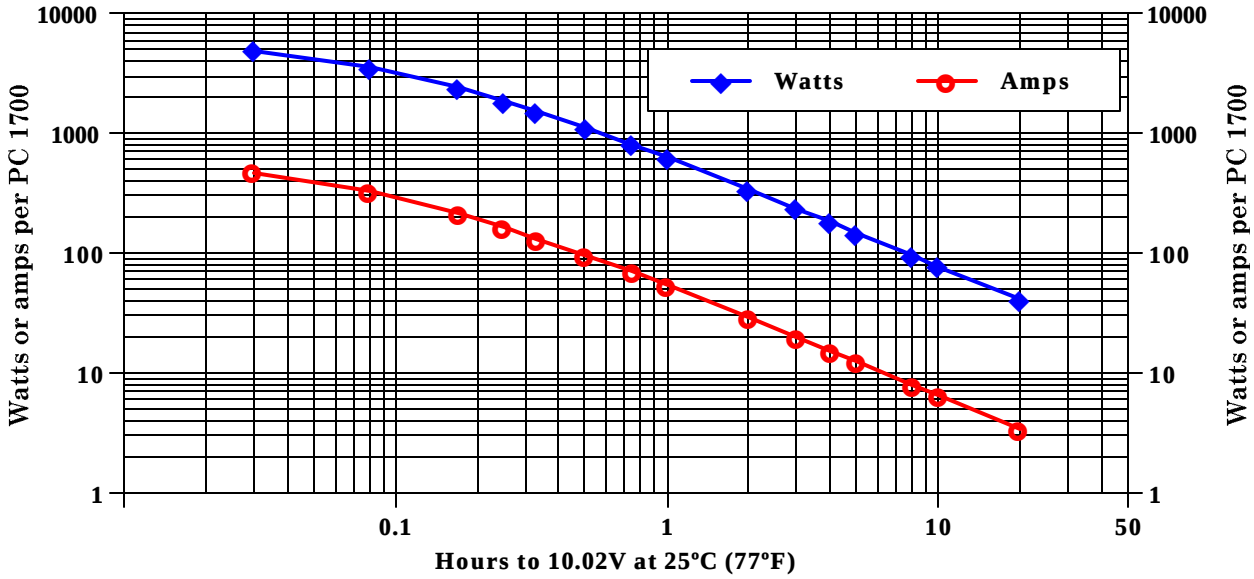

ODYSSEY® PC 1700 performance data at 25°C, per 12V module

Time to 10.02V	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	Energy and power densities			
					W/lit.	Wh/lit.	W/kg.	Wh/kg.
2 min	5131	494.0	16.5	155.8	530.5	15.9	208.6	6.3
5 min	3636	328.0	28.2	294.4	376.0	30.1	147.8	11.8
10 min	2412	217.0	36.5	428.3	257.4	43.8	101.2	17.2
15 min	1836	164.0	41.0	485.1	198.2	49.6	77.9	19.5
20 min	1488	132.0	44.0	523.7	162.1	53.5	63.7	21.0
30 min	1092	96.1	48.1	586.5	119.8	59.9	47.1	23.6
45 min	786	68.6	51.5	637.6	86.9	65.1	34.1	25.6
1 hr	618	53.5	53.5	670.2	68.5	68.5	26.9	26.9
2 hr	333	28.9	57.8	735.6	37.6	75.2	14.8	29.5
3 hr	229	19.9	59.7	768.6	26.2	78.5	10.3	30.9
4 hr	175	15.2	60.8	789.6	20.2	80.7	7.9	31.7
5 hr	142	12.4	62.0	807.0	16.5	82.4	6.5	32.4
8 hr	90	8.0	64.0	840.0	10.7	85.8	4.2	33.7
10 hr	73	6.5	65.0	858.0	8.8	87.7	3.4	34.5
20 hr	37	3.4	68.0	936.0	4.8	95.6	1.9	37.6

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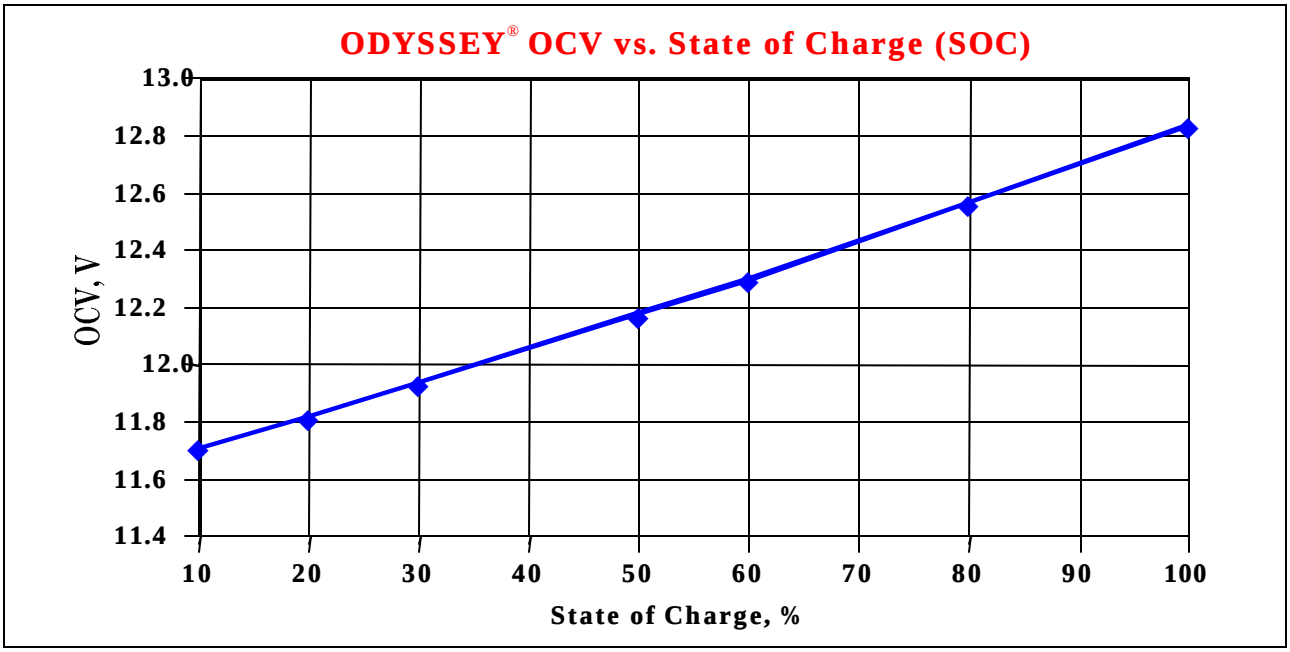
ODYSSEY® storage and deep discharge recovery characteristics

For any rechargeable battery, storage and recharge are important criteria, and this section develops some useful guidelines that should be followed.

(A) How do I know the state of charge (SOC) of the battery?

Provided the battery has not been charged or discharged for several hours, one can use the following graph to determine the SOC of the ODYSSEY® battery. The only tool needed is a good quality digital voltmeter to measure its open circuit voltage (OCV). The graph indicates that a healthy, fully charged ODYSSEY® battery will have an open circuit voltage of **12.84V or higher at 25°C**

The open circuit voltage (OCV) numbers on this graph are applicable only if the battery has not seen any activity (charge or discharge) for at least a few hours before voltage measurements are taken.



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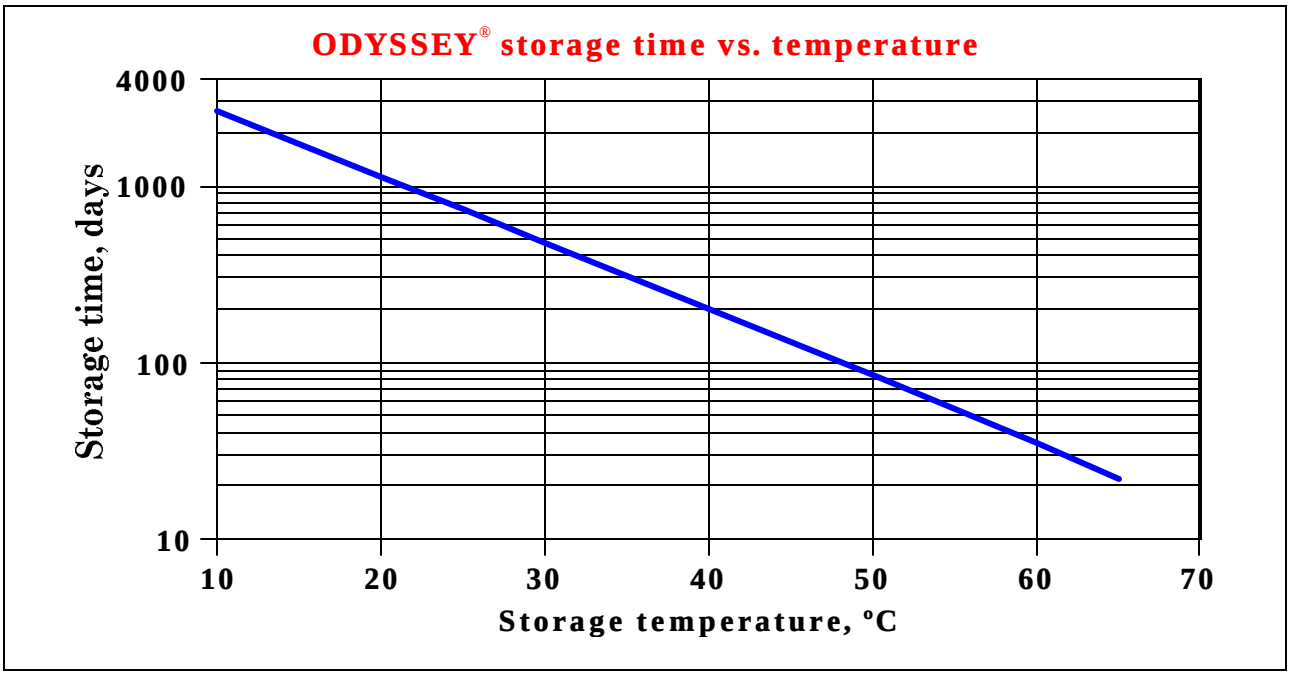
(B) How long can the battery be stored?

The next graph shows the remarkable storage properties of the ODYSSEY® battery. At a temperature of 25°C, one can store these batteries for up to two years. The lower the temperature, the longer the storage time. ***The battery must be charged before storage***.

The impact of temperature on storage is also shown. Roughly every 10°C or 18°F increase in temperature cuts the storage time in half. Thus, although the ODYSSEY® battery may be kept on the shelf for two years at 25°C (77°F), if the temperature rises to about 35°C (95°F) the battery may be stored for only one year before it needs a recharge.

The numbers on this graph are applicable only if the battery is fully charged before being placed on storage.



(C) Can the battery recover from abusive storage conditions?

The short answer is yes, the ODYSSEY® battery **can** recover from extremely deep discharges as the following tests demonstrate.

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(1) German DIN standard test for overdischarge recovery

In this test, a charged PC 925 was discharged over 20 hours ($0.05C_{10}$ rate) to 10.20V. After the discharge[4] was complete, a 5Ω resistor was placed across the battery terminals and it was set aside for 28 days.

At the end of 28 days' of storage, the battery was charged at 13.5V for only 48 hours. Another $0.05C_{10}$ discharge yielded 97% of rated capacity, indicating that a low rate 48-hour charge after such as deep discharge was not sufficient; however, the test is designed to show whether the battery can be recovered from extremely deep discharges using only a standby float charger. A standard automotive charger at 14.4V would have allowed the battery to recover greater than 97% of its capacity.

The results of this test conclusively prove that ODYSSEY® batteries can recover from very abusive storage conditions. This conclusion is further reinforced by the following test that is even harsher than the DIN standard test due to the fact that the battery was stored in a discharged state at a temperature of 50°C or 112°F.

(2) High temperature (50°C/112°F) discharged storage test

In this test two battery samples were discharged at the 1-hour rate to 9V per module, then set aside for storage at 50°C (112°F) in a ***discharged condition*** for four weeks.

At the end of four weeks the two batteries were recharged using a constant voltage (CV) charger at 14.7V per battery. As the graph below shows, both samples were able to recover nicely from this extreme case of abusive storage.

[4] The C_{10} rate of charge or discharge current in amperes is numerically equal to the rated capacity of a battery in ampere-hours at the 10-hour rate. Thus a 26Ah battery at the 10-hour rate, such as the PC 925 would have a C_{10} rate of 26A.

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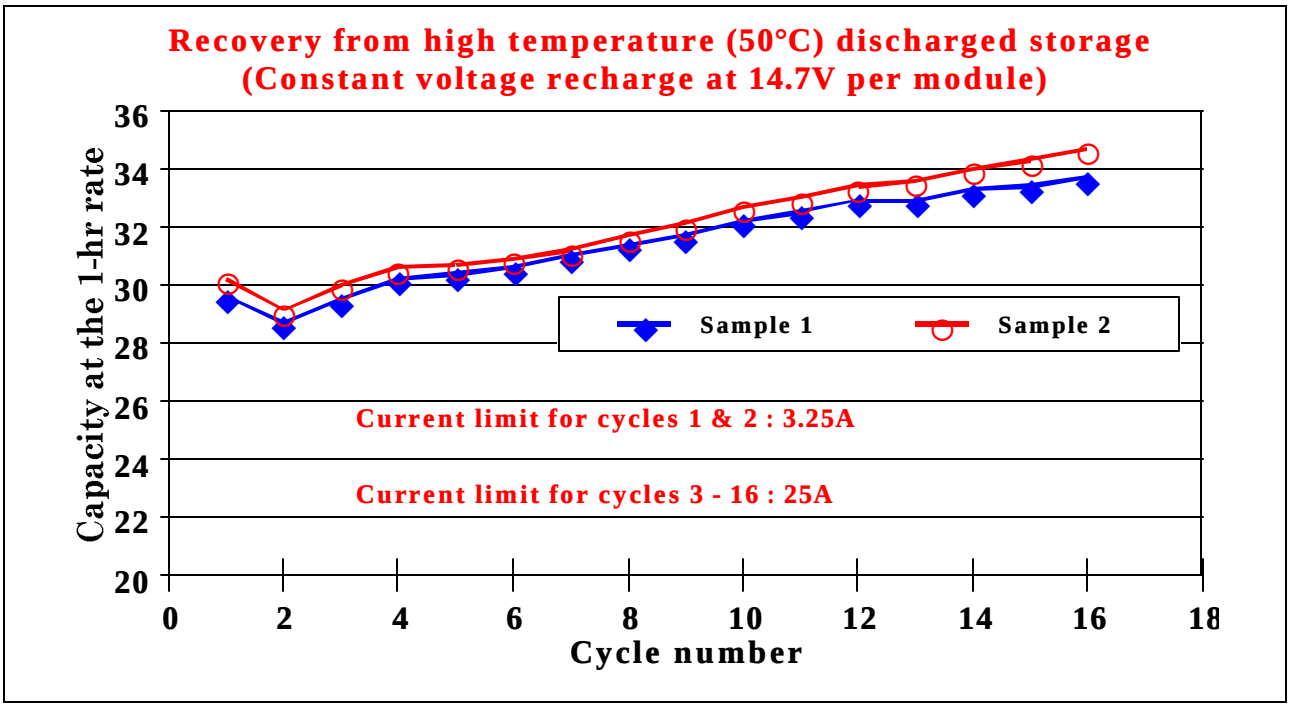

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Parasitic loads

In more and more applications the phenomenon of ***parasitic loads*** is showing its ugly head. So, what are parasitic loads?

Parasitic loads are small currents, typically with a magnitude of a few milliamperes (mA), that the battery continuously delivers for various reasons. Holding up memories and operating security systems are common examples of parasitic drains on batteries.

Even though the current drains are low, their impact on a long-term basis can be significant when the battery has to provide the drain for weeks or even months at a time. An example will make this clear.

In some models of Sea-Doo personal watercraft the drain on the battery, with the engine switched off and the battery connected, varies from 7mA to 18mA, depending on whether or not the lanyard is installed. If the watercraft were equipped with a PC 625, it would take 95 days to be fully discharged at the 7mA rate; at the 18mA rate it will lose 100% of its capacity in only 37 days. Since the PC

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625 needs to have at least 30% of its capacity to crank the engine, the maximum number of days that a parasitic load can be tolerated is less than the numbers given above. Table II below shows the number of days needed to reduce the battery's state of charge (SOC) to 0% and 30% with an 18mA parasitic load. Should the parasitic load on your vehicle be some value other than 18mA, prorate the number of days given in Table II. If, for example, the load is 10mA, multiply all days in the table by the fraction 10/18 or 0.56. ***This table assumes that the ODYSSEY® battery is fully charged when placed on storage***.

Table II: Effect of an 18mA parasitic load on storage of ODYSSEY® batteries

	PC 535	PC 545	PC 625	PC 680	PC 925	PC 1200	PC 1700
Days to 0% SOC	32	30	37	37	60	97	162
Days to 30% SOC	22	21	26	26	42	68	113

Table II shows how critically important it is to make sure that your battery is not being drained by a parasitic load; if it is being slowly drained, the battery ***must be connected to a float (trickle) charger that will help compensate such capacity losses. Alternatively, physically disconnect one of the battery cables to interrupt the small drain***.

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Shock, impact and vibration testing of ODYSSEY® batteries

The ODYSSEY® battery has been subjected to several tests that prove their high resistance to shock and vibration.

(A) MIL S-901C shock, high impact test

This is a test specified by the US Navy to determine suitability of equipment to be installed on warships. A 26Ah battery (equivalent to the PC 925 but without the metal jacket) was installed in an UPS system aboard a Navy MHC51 class coastal mine hunter.

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The object of this test is to simulate the shock generated by a 16-in. naval gun and a depth charge going off simultaneously. Testing is performed by hitting the UPS, while in operation, with a 2,500 lb. hammer from varying distances. After several such impacts the battery system was load tested for proper functioning.

The 26Ah battery passed the test without metal jackets. Equipping the ODYSSEY® batteries with metal jackets will only increase their ability to withstand harsh shock and impact situations that may be encountered in automotive applications.

(B) MIL S-167-1 for mechanical vibrations

The Drycell™ batteries were subjected to three classes of vibration — *exploratory vibration*, *variable frequency* and *endurance test*.

Exploratory vibration test

The UPS unit containing the battery was vibrated from 5Hz to 33Hz at a table vibratory single amplitude of 0.010 ± 0.002 in., in discrete frequency intervals of 1Hz. Vibration at each frequency was maintained for 15 seconds.

Variable frequency test

The UPS unit was vibrated from 5Hz to 33Hz at 1Hz intervals at different amplitudes. At each frequency the vibration was maintained for 5 minutes.

Endurance test

The test was conducted at 33Hz for two hours in the *x*- and *y*- axes at a table vibratory double amplitude of 0.010 ± 0.002 in. The *z*-axis endurance test was conducted at 33Hz for two hours at a table vibratory single amplitude of 0.020 ± 0.004 inch.

(C) Ford vehicle vibration test

Two batteries, equivalent to the PC 925 and PC 1200 were mounted in a special fixture and tested per the following parameters:

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Test direction	Frequency, Hz	Acceleration, g	Duration, min.
Vertical	10 - 12	3	40
Transverse	10 - 17	3	40
Horizontal	15 - 30	3	40

None of the four batteries showed noticeable failures at the end of the test.

(D) Three axis vibration test

This test was conducted for Hawker Energy Products Inc. by an independent test facility. Two batteries, equivalent to the PC 925 and PC 1200 were mounted in a special fixture and tested in the following manner:

Test direction	Frequency, Hz	Acceleration, g	Duration, hrs.
Vertical	33	3	2
	33	4	2
	33	6	2
Transverse	33	3	2
	33	4	2
	33	6	2
Horizontal	33	3	2
	33	4	2
	33	6	2

Once again none of the four batteries showed any noticeable failures at the end of this test.

Summarizing on the basis of tests described in this section, there is little doubt about the ability of the ODYSSEY® Drycell™ battery to withstand substantial levels of mechanical abuse. This in itself is a very desirable feature in SLI batteries.

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Charging ODYSSEY® batteries

A critical factor in the proper use of a rechargeable battery is charging. Inadequate or improper charging is the most common cause of premature failure of rechargeable lead acid batteries.

To ensure proper charging of your premium ODYSSEY® battery, Deltran Corporation[5] and Hawker Energy Products Inc. have developed a special charge algorithm that is designed to rapidly and safely charge these batteries. They are available in 6A, 10A, 15A and 20A versions. Since these are automatic chargers no manual intervention is necessary. We suggest the following Deltran chargers to get peak performance from your ODYSSEY® battery.

Charger rating	*Recommended ODYSSEY® model*
6A charger	**Use on PC 535 / PC 545 / PC 625 / PC 680**
10A charger	**Use on PC 925 or smaller battery**
15A charger	**Use on PC 925 / PC 1200 or smaller battery**
20A charger	**Use on PC 1700 or smaller battery**

As an alternative, small, portable automotive chargers may also be used to charge your ODYSSEY® battery. These chargers are essentially designed to bring a discharged battery to a state of charge (SOC) that is high enough to crank an engine. Once this is successfully accomplished it is up to the engine alternator to fully charge the battery. It is important to keep this design philosophy in mind when using this type of charger.

There is another class of chargers that is designed specifically to maintain the battery in a high state of charge. ***These chargers, such as the .75 amp or 1.25 amp Battery Tender® from Deltran are not capable of charging a deeply discharged ODYSSEY® battery.*** This is due to the fact that these chargers have very low power handling capability. They should only be used either to continuously compensate for parasitic losses or to maintain a trickle charge on a stored battery. It is very important,

[5] Deltran may be contacted at (386) 736-7900 or by fax at (386) 736-0379 or online at www.batterytender.com

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therefore, to ensure that the ODYSSEY® battery is fully charged before this type of charger is connected to it.

(A) Selecting the right charger for your battery

Although Deltran chargers are recommended for use with ODYSSEY® batteries, small, portable automotive chargers can also be used, as long as certain suitability criteria are met. Qualifying these chargers for your ODYSSEY® battery is a simple two-step process.

Step 1 Charger output voltage

Determining the charger output voltage is the most important step in the charger qualification process. **IF THE VOLTAGE OUTPUT FROM THE CHARGER IS LESS THAN 14.2V OR MORE THAN 15V FOR A 12V BATTERY DO NOT USE THE CHARGER.** For 24V battery systems the charger output voltage should be between 28.4V and 30V. If the charger output voltage falls within these voltage limits when the battery approaches a fully charged state, proceed to Step 2; otherwise pick another charger.

Step 2 Charger type — automatic or manual

The two broad types of small, portable chargers available today are classified as either ***automatic*** or ***manual***. Automatic chargers can be further classified as those that charge the battery up to a certain voltage and then shut off and those that charge the battery up to a certain voltage and then switch to a lower float (trickle) voltage.

An example of the first type of automatic charger is one that charges a battery up to 14.2V, then immediately shuts off. An example of the second type of automatic charger would bring the battery up to 14.2V then switch to a float (trickle) voltage of 13.6V; it will stay at that level indefinitely. The second type of automatic charger is preferred as the first type of charger is likely to undercharge the battery.

A manual charger typically puts out a single voltage or current level continuously and has to be manually switched off to prevent battery overcharge. **Should you choose to use a manual charger with your ODYSSEY® battery, DO NOT exceed charge times suggested in Table III below.**

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(B) Selecting battery type on your charger output

While it is not possible to cover every type of battery charger available today in a product guide such as this, this section will try to give the ODYSSEY® battery user some general charger usage guidelines to follow, ***after the charger has been qualified for use with this battery.***

In general, do not use either the gel cell or maintenance free setting, if provided on your charger. Choose the deep cycle option, should there be one on your charger. Table III below provides suggestions on charge times based on charger currents. ***For maximum life from your ODYSSEY® battery, after completing the charge time in Table III, we recommend that you switch your charger to the 2A trickle charge position and leave the battery connected to the charger for an additional six to eight hours.***

Table III: Suggested charge times for ODYSSEY® batteries

Model	Charge time for 100% discharged battery	
	10A charger	20A charger
PC 535	1½ hr.	45 min.
PC 545	1½ hr.	45 min.
PC 625	2 hr.	1 hr.
PC 680	2 hr.	1 hr.
PC 925	2½ hr.	1¼ hr.
PC 1200	4 hr.	2 hr.
PC 1700	7 hr.	3½ hr.

Note that the charge times recommended in Table III are based on an assumption that the ODYSSEY® battery is fully discharged and these charge times will only bring the battery to a 90% state of charge. If the battery is only partially discharged the charge times should be appropriately reduced. The graph on page 16, showing open circuit voltage and state of charge (SOC) should be used to determine the SOC of your battery. The battery should, however, be trickle charged (2A setting) after high rate charging regardless of its initial SOC.

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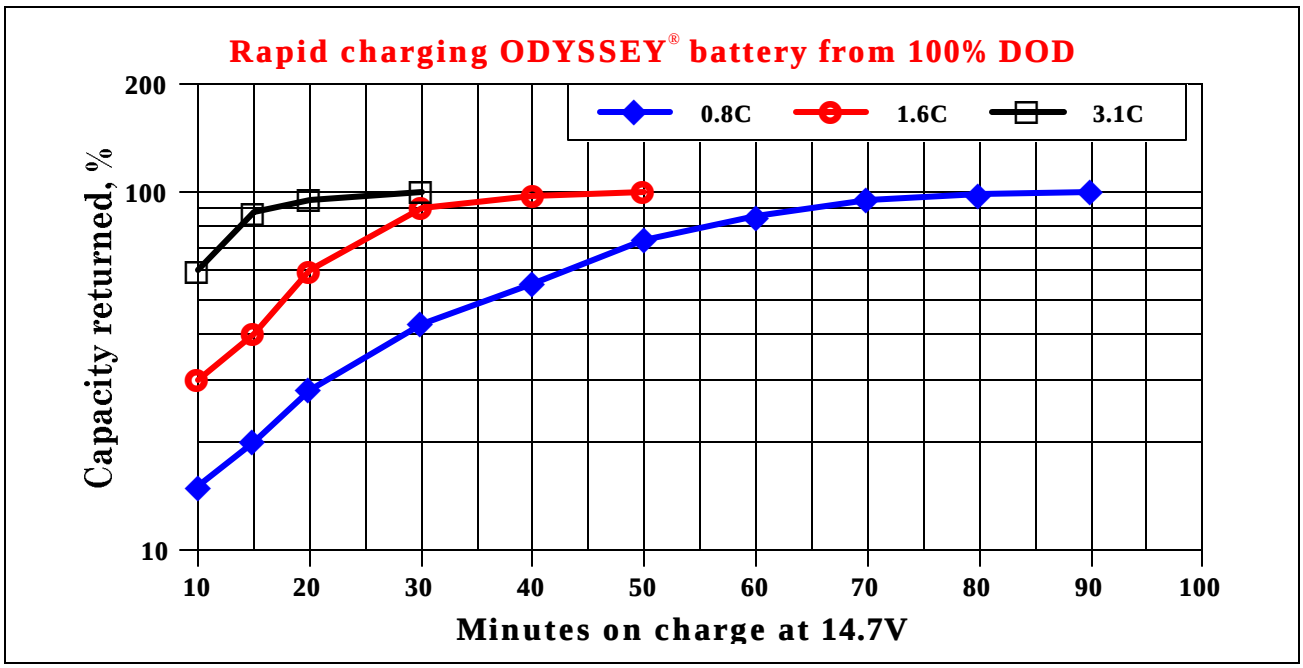
Rapid charging of ODYSSEY® batteries

All ODYSSEY® batteries can be quick charged. The graph below shows its exceptional fast charge characteristics when charged at a constant 14.7V, at three levels of inrush current. This voltage level of 14.7V is very similar to the output of a modern automotive alternator. Table IV and the following the graph illustrates the capacity returned as a function of the magnitude of the inrush[6] current.

Table IV

Capacity returned	Inrush current magnitude		
	$0.8C_{10}$	$1.6C_{10}$	$3.1C_{10}$
60%	44 min.	20 min.	10 min.
80%	57 min.	28 min.	14 min.
100%	90 min.	50 min.	30 min.



[6] The magnitude of the inrush is defined in terms of the rated capacity (C_{10}) of the battery. Thus, a $0.8C_{10}$ inrush implies a current that is 80% of the rated capacity, or 80A for a 100Ah battery. Similarly, a $1.6C_{10}$ inrush on a 100Ah battery means that the charge current inrush is 160A (1.6 X 100).

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The table above shows that with a $0.8C_{10}$ inrush current, a 100% discharged battery can have 80% of its capacity returned in 57 minutes; doubling the inrush to $1.6C_{10}$ cuts the time taken to reach 80% capacity to only 28 minutes.

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Concluding remarks

We believe that there is no other sealed-lead battery currently available commercially that can match the ODYSSEY® battery for sheer performance and reliability. We hope that the preceding material will help the reader arrive at the same conclusion.

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Frequently asked SLI battery questions

What is the CCA rating?

The cold cranking ampere (CCA) rating refers to the number of amperes a battery can support for 30 seconds at a temperature of 0°F (–18ºC) until the battery voltage drops to 1.20 volts per cell, or 7.20 volts for a 12V battery. A 12V battery that has a rating of 600 CCA means that the battery will provide 600 amps for 30 seconds at 0°F (–18ºC) before the voltage falls to 7.20V.

What is the MCA rating?

The marine cranking amp (MCA) rating refers to the number of amps a battery can support for 30 seconds at a temperature of 32°F (0ºC) until the battery voltage drops to 7.20 volts for a 12V battery. A 12V battery that has a MCA rating of 600 CCA means that the battery will provide 600 amps for 30 seconds at 32°F (0ºC) before the voltage falls to 7.20V.

The MCA is sometimes called the cranking amperes or CA.

What is a HCA rating?

The abbreviation HCA stands for ***hot cranking amps***. It is the same as MCA, CA or CCA, ***except that the temperature at which the test is conducted is 80°F (26.7ºC).***

What is the PCA rating?

Unlike CCA and MCA the pulse cranking amp (PCA) rating does not have an "official" definition; however, we believe that for true SLI purposes, a 30-second discharge is unrealistic. The PCA, a short duration (about 3 to 5 seconds) high rate discharge, is more realistic. Because the discharge is for such a short time, it is more like a pulse.

Are these gel cells? What's the difference?

No, the ODYSSEY® is **NOT** a gel cell. It is an absorbed electrolyte type battery, meaning that ***there is no free acid inside the battery; all of the acid is kept absorbed in the glass mat separators***. These separators serve to keep the positive and negative plates apart.

The key difference between the gel cell and the absorbed glass mat (AGM) cell lies in the fact that in the AGM cell all of the electrolyte is in the separator, whereas in the gel cell the acid is within the cells in a gel form. If the ODYSSEY® battery were to split open, there would be no acid

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spillage! That is why we call the ODYSSEY® a Drycell™!

Please explain the Ah rating.

The ampere-hour (Ah) rating defines the capacity of a battery. A battery that is rated as a 100Ah battery at the 10 hour rate of discharge is capable of delivering 10A for 10 hours before the terminal voltage drops to a standard value such as 10.02 volts for a 12V battery. The PC 1200 battery is rated at 42Ah, so it can deliver 4.2A for 10 hours.

What is reserve capacity rating?

The reserve capacity of a battery is the number of minutes it can support a 25-ampere load at 80°F until its terminal voltage drops to 10.50 volts for a 12V battery. Thus a 12V battery that has a reserve capacity rating of 100 signifies that it can be discharged at 25 amps for 100 minutes at 80°F before its voltage drops to 10.75 volts.

Is ODYSSEY® a dry battery?

Because the ODYSSEY® battery has no free acid inside, it is exempted from the requirements of 49 CFR § 173.159 of the US Department of Transportation (USDOT). The battery also enjoys a **"nonspillable"** classification and falls under the International Air Transport Association (IATA) "unrestricted" air shipment category. These batteries may be shipped completely worry-free. Supporting documentation is readily available.

What is impedance?

The impedance of a battery is a measure of how easily it can be discharged. The lower the impedance the easier it is to discharge the battery. The impedance of the ODYSSEY® battery is considerably less than that of a conventional SLI battery, so its high rate discharge capability is significantly higher than that of a conventional SLI battery.

How much current is generated if I accidentally short this battery?

As suggested before, this battery has very low impedance, meaning that the short circuit current can be very high. For a PC 925 battery, the short circuit current can be as high as 2,500 amperes.

Do I ruin the battery if I accidentally drop it? Does it void the warranty?

Not necessarily, but it is possible to damage the internal connections sufficiently to damage the battery. Our warranty applies only to manufacturing defects and workmanship issues; the policy does not cover damages suffered due to product mishandling.

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What is so special about pure lead tin technology? Is it a new technology?

The answer lies in the very high purity (99.99%) of our raw lead materials, making our product very special. The technology is not new; the sealed lead recombinant technology was invented and patented by us back in 1973.

Why don't you have to winterize your batteries? What's so special about them?

In general, winterizing refers to a special maintenance procedure conducted on an automobile engine to insure its reliability during the coming winter season. This procedure essentially checks the engine's cooling system; in addition, the battery is load tested according to a specific method laid out by the Battery Council International (BCI). While ODYSSEY® batteries do not specifically require this test to be conducted on them, the final decision whether or not to conduct this test is left to the user's discretion.

Are these Ni-Cd batteries? Why doesn't somebody make these in Ni-Cd? Wouldn't they charge faster with Ni-Cd?

No, the ODYSSEY® is **NOT** a Ni-Cd battery. It is a sealed lead battery. In general, Ni-Cd batteries are much more expensive to manufacture and recycle, so they are less cost effective than a lead acid product.

A Ni-Cd battery would charge faster than a conventional lead acid battery; however, the ODYSSEY® is **NOT** a conventional battery and its charge characteristics are somewhat similar to nickel cadmium batteries. In fact, with a powerful enough charger, it is possible to bring ODYSSEY® batteries to better than 95% state of charge in less than 20 minutes! That is very comparable to the fast charge capabilities of a nickel cadmium product.

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