ODYSSEY™

THE EXTREME BATTERY

APPLICATION MANUAL

STARTING, LIGHTING & IGNITION (SLI) DRYCELL™ BATTERY GUIDE

SIXTH EDITION

Publication No: US-ODY-AM-001 - April 2006

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Preface to the Sixth Edition

The addition of four new members to the ODYSSEY™ family of premium batteries - the PC310, the PC1500 (a true BCI Group 34/78), the PC2150 (a true BCI Group 31 size) and the PC2250 - has necessitated this new edition. Just as in the previous editions of the battery guide, detailed performance data for the new batteries are included in this revision.

This edition provides an expanded treatment of the charging requirements for ODYSSEY batteries, including a detailed discussion of a three-step charge profile that will bring back a fully discharged battery in about 6 to 8 hours. Also discussed are design variations among chargers with this profile.

This edition also includes updated test data on ODYSSEY batteries.

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Introduction

The ODYSSEY battery ingeniously uses absorbed glass mat (AGM) valve regulated lead acid (VRLA) technology to offer, in one package, the characteristics of two separate batteries. It can deep cycle as well as deliver serious cranking power - it is like an athlete who is both a champion long distance runner and an excellent sprinter. Traditional battery designs allow them to either deep cycle or provide high amperage discharges for applications such as engine starting. The ODYSSEY battery can support applications in either category. ODYSSEY batteries are capable of providing engine cranking pulses of up to 2,250A for 5 seconds at 25ºC (77ºF) as well as deliver 400 charge/discharge cycles to 80% depth of discharge (DOD) when properly charged. A typical starting, lighting and ignition (SLI) battery, for example, is designed to provide short-duration, high-amperage pulses; it performs poorly when repeatedly taken down to deep depths of discharge or if they are placed on a continuous trickle charge, such as when they are used to crank a backup generator. A traditional battery resembles either a sprinter or a long distance runner; an ODYSSEY battery will do both - provide short duration high amperage pulses or low rate, long duration drains.

Why use ODYSSEY Batteries?

Guaranteed longer service life

With a 10 to 12-year design life and a 3 to 8-year service life, ODYSSEY batteries save you time and money because you do not have to replace them as often. Unlike other AGM VRLA batteries, the ODYSSEY battery is capable of delivering up to 400 cycles when discharged to 80% DOD and properly charged.

Longer storage life

Unlike conventional batteries that need a recharge every 6 to 12 weeks, a fully charged ODYSSEY battery can be stored for up to 2 years at 25°C (77°F) from a full state of charge. At lower temperatures, storage times will be even longer.

Deep discharge recovery

The ease with which an ODYSSEY battery can recover from a deep discharge is extraordinary. A later section on storage and recharge criteria discusses test data on this important topic.

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 (-40ºF). In addition, with simple constant voltage charging there is no need to limit the inrush current, allowing the battery to be rapidly charged. Please see the section titled *Rapid charging of ODYSSEY batteries* for more details on this feature.

Easy shipping

The AGM valve-regulated design of the ODYSSEY battery eliminates the need for vent tubes; further, no battery watering is required and there is no fear of acid burns or damage to expensive chrome or paint. Because of the starved electrolyte design, the US Department of Transportation (USDOT) has classified the ODYSSEY battery as a dry battery. Shipping these batteries by express ground or by air is possible.

Tough construction

The rugged construction of the ODYSSEY battery makes it suitable for use in a variety of environments ranging from vacuum to 2 atmospheres (29.4 PSI).

Mounting flexibility

Installing the ODYSSEY battery in any orientation does not affect any performance attribute. There is also no fear of acid spillage. However, inverted installation is not recommended.

Superior vibration resistance

ODYSSEY batteries have passed a variety of rigorous tests that demonstrate their ruggedness and exceptional tolerance of mechanical abuse. Please see the section titled *Shock, impact and vibration testing* for more details on these tests.

Ready out of the box

ODYSSEY batteries ship from the factory fully charged. If the battery's open circuit voltage is higher than 12.65V, simply install it in your vehicle and you are ready to go; if below 12.65V boost charge the battery following the instructions in this manual or the owner's manual. For optimum reliability, a boost charge prior to installation is recommended, regardless of the battery's open circuit voltage (OCV).

Specifications

Feature	Model (Ah @ 10-hour rate/Ah @ 20-hour rate)										
	PC310 (7/8)	PC535 (13/14.8)	PC545 (12/14)	PC625 (17/18)	PC680 (16/17)	PC925 (27/28)	PC1200 (41/44)	PC1500 (62/68)	PC1700 (65/68)	PC2150 (97/104)	PC2250 (114/126)
5 sec. pulse hot cranking amps (PHCA)	310	535	545	625	680	925	1,200	1,500	1,700	2,150	2,250
CCA @ 0°F	100	200	185	265	220	380	550	825	875	1,090	1,225
CA @ 32°F	155	265	240	350	300	500	725	1,050	1,175	1,370	1,550
HCA @ 80°F	200	300	300	440	370	625	860	1,250	1,325	1,545	1,730
Charge voltage	Float voltage: 13.5V to 13.8V at 25°C (77°F); no current limit Cyclic voltage: 14.4V to 15.0V at 25°C (77°F); no current limit										
Reserve capacity, minutes	9	21	18	27	24	52	78	125	142	200	240
Terminals	M4 bolt	M6 bolt	M6 bolt	M6 stud	M6 bolt or SAE 3/8″ receptacle		M6 bolt or SAE 3/8″ receptacle	Top SAE 3/8″ Side: 3/8″ X 16 receptacle	M6 bolt SAE 3/8″ receptacle or 5/16″ SS stud	3/8″ stud /SAE	Dual SAE/DIN terminal and 3/8″ stud
Terminal torque, in-lbs.	8.9	40	50	40	50	60	60	70	60	150-200	100
Length, in. (mm.)	5.43 (138.0)	6.70 (170.2)	7.00 (177.8)	6.70 (170.2)	7.27 (184.7)	6.64 (168.6)	7.87 (199.9)	10.85 (275.6)	13.02 (330.7)	13.00 (330.2)	11.26 (286.0)
Width, in. (mm.)	3.39 (86.0)	3.90 (99.1)	3.37 (85.6)	3.90 (99.1)	3.11 (79.0)	7.05 (179.0)	6.66 (169.1)	6.99 (177.5)	6.62 (168.2)	6.80 (172.7)	10.59 (269.0)
Height, in. (mm.)	3.98 (101.0)	6.125 (155.6)	5.17 (131.3)	6.89 (175.0)	6.67 (169.4)	5.04 (128.0)	6.80 (172.7)	7.82 (198.6)	6.93 (176.0)	9.4 (238.8)	9.17 (233.0)
Weight, lb. (kg.)	5.9 (2.7)	12.0 (5.4)	12.6 (5.7)	13.2 (6.0)	15.4 (7.0)	26.0 (11.8)	38.2 (17.4)	53.0 (24.0)	60.9 (27.6)	75.0 (34.1)	86.0 (39.0)
Cycle life @ 77°F	400 cycles to 80% depth of discharge, with correct charge profile										
Temperature range	-40°C (°F) to 45°C (113°F) for PC535 & PC625 -40°C (°F) to 80°C (176°F) with metal jacket on all other models, except PC310, PC535 and PC625 -40°C (°F) to +50°C (122°F) for PC310							-40°C (°F) to 80°C (176°F) with metal jacket on all models, except PC2250 -30°C (-22°F) to +40°C (104°F) for PC2250			
Resistance @ 1kHz at 77°F	27.1m	8.0m	10.0m	7.0m	7.0m	5.0m	4.5m	2.5m	3.5m	2.2m	2.1m
Short circuit amps	455	1,000	1,200	1,800	1,800	2,400	2,600	3,100	3,500	5,000	5,000

NOTE: Metal jackets are not available for PC310, PC535, PC625, PC1500, and PC2250

Pulse discharge capabilities

Figure 1 shows the excellent short duration or pulse discharge capabilities of the ODYSSEY family of batteries. Note that successive discharges must be spaced apart to allow the terminals to cool down. Second, the graph reflects the capabilities of fully charged batteries at a temperature of 25°C (77ºF).

Table 1 shows the 5, 10, 20 and 30-second pulse discharge rates for these batteries.

Figure 1: Pulse discharge capability

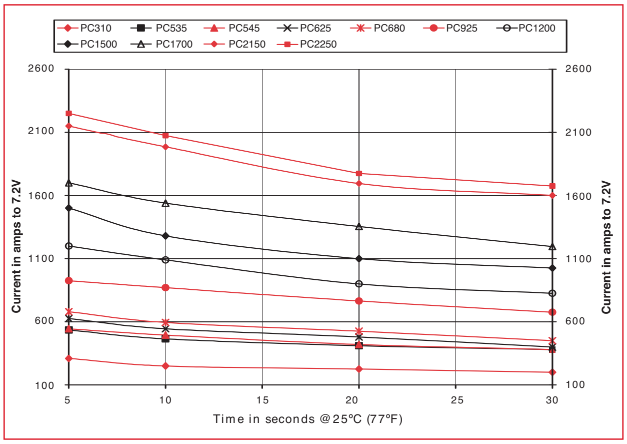


Table 1: Pulse discharge of ODYSSEY batteries

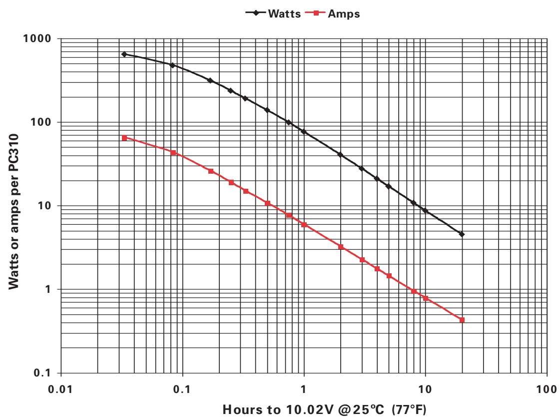
	Pulse discharge in amps to 7.2V @25°C (77°F)			
Battery	**5 Sec.**	**10 Sec.**	**20 Sec.**	**30 Sec.**
PC310	310	250	225	200
PC535	535	465	410	380
PC545	545	495	420	380
PC680	680	595	525	400
PC625	625	545	480	450
PC925	925	870	765	675
PC1200	1,200	1,090	900	825
PC1500	1,500	1,280	1,100	975
PC1700	1,700	1,540	1,355	1,195
PC2150	2,150	1,985	1,750	1,600
PC2250	2,250	2,075	1,775	1,675

Extended discharge characteristics

In addition to its excellent pulse discharge capabilities, the ODYSSEY battery can deliver many deep discharge cycles, yet another area where the ODYSSEY battery outperforms a conventional SLI battery, which can deliver only a few deep discharge cycles.

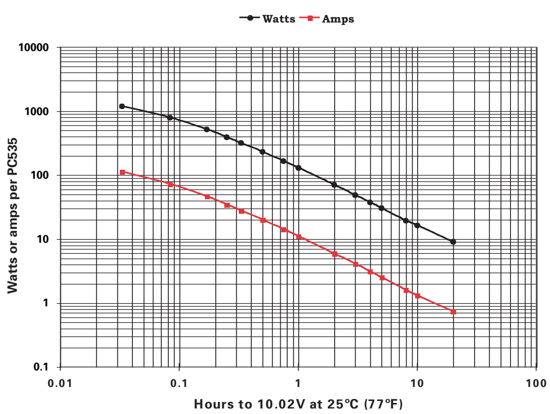
The following ten graphs show detailed discharge characteristics of the entire ODYSSEY line. The end of discharge voltage in each case is 10.02V per battery or 1.67 volts per cell (VPC). Each graph shows both constant current (CC) and constant power (CP) discharge curves at 25ºC (77ºF). The table below each graph shows the corresponding energy and power densities. The battery run times extend from 2 minutes to 20 hours.

PC310 performance data at 25°C, per module



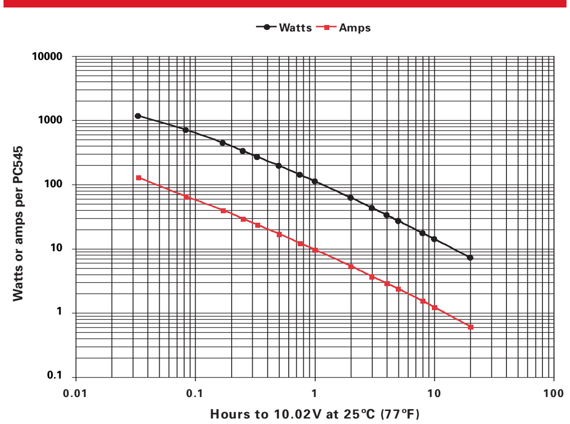
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES W/liter	Wh/liter	W/kg	Wh/kg
2 min	738	80.8	2.7	24.6	613.2	20.4	273.3	9.1
5 min	473	43.2	3.6	39.4	393.3	32.8	175.3	14.6
10 min	312	26.0	4.4	53.1	259.4	44.1	115.6	19.7
15 min	236	19.0	4.8	59.0	196.0	49.0	87.4	21.8
20 min	191	15.0	5.0	62.9	158.4	52.3	70.6	23.3
30 min	139	10.8	5.4	69.3	115.1	57.6	51.3	25.7
45 min	98	7.6	5.7	73.9	81.8	61.4	36.5	27.4
1 hr	76	6.0	6.0	76.4	63.5	63.5	28.3	28.3
2 hr	41	3.2	6.5	81.0	33.7	67.3	15.0	30.0
3 hr	28	2.3	6.8	82.8	22.9	68.8	10.2	30.7
4 hr	21	1.8	7.0	83.7	17.4	69.6	7.8	31.0
5 hr	17	1.4	7.2	84.5	14.0	70.2	6.3	31.3
8 hr	11	0.9	7.6	86.1	8.9	71.5	4.0	31.9
10 hr	9	0.8	7.8	86.8	7.2	72.1	3.2	32.2
20 hr	5	0.4	8.6	90.5	3.8	75.2	1.7	33.5

PC535 performance data at 25°C, per 12V module



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES W/liter	Wh/liter	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

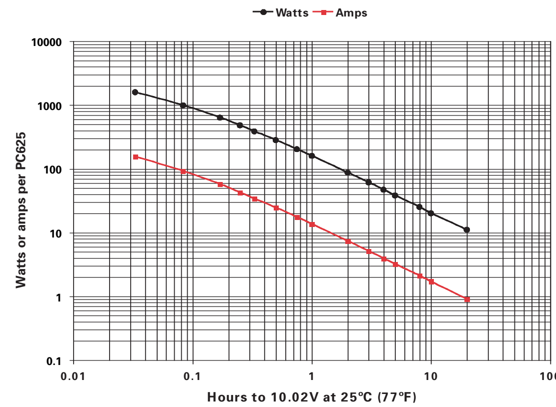
PC545 performance data at 25°C, per 12V module



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES W/liter	Wh/liter	W/kg	Wh/kg
2 min	1361	128.1	4.3	45.3	680.8	22.7	238.7	8.0
5 min	648	64.4	5.4	54.0	324.2	27.0	113.7	9.5
10 min	415	39.6	6.7	70.6	207.75	35.3	72.8	12.4
15 min	313	29.2	7.3	78.2	156.4	39.1	54.8	13.7
20 min	254	23.5	7.8	83.8	127.0	41.9	44.5	14.7
30 min	187	16.9	8.5	93.3	93.4	46.7	32.7	16.4
45 min	136	12.2	9.2	101.7	67.9	50.9	23.8	17.8
1 hr	107	9.6	9.6	107.4	53.7	53.7	18.8	18.8
2 hr	60	5.3	10.6	120.0	30.0	60.0	10.5	21.1
3 hr	42	3.7	11.1	126.0	21.0	63.1	7.4	22.1
4 hr	32	2.9	11.6	129.6	16.2	64.9	5.7	22.7
5 hr	26	2.3	11.5	132.0	13.2	66.1	4.6	23.2
8 hr	17	1.5	12.0	134.4	8.4	67.25	3.0	23.6
10 hr	14	1.2	12.0	138.0	6.9	69.1	2.4	24.2
20 hr	7	0.7	14.0	144.0	3.6	72.1	1.3	25.3

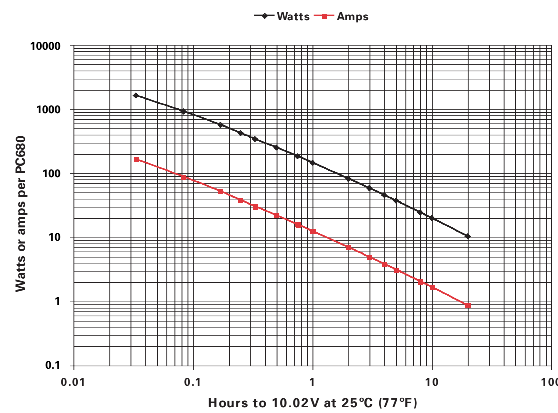
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/liter	Wh/liter	W/kg	Wh/kg
2 min	1582	154.7	5.20	52.70	536.10	17.90	255.10	8.50
5 min	986	91.6	7.60	82.20	334.35	27.90	159.10	13.30
10 min	635	57.1	9.50	105.90	215.40	35.90	102.50	17.10
15 min	478	42.3	10.60	119.40	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

PC625 performance data at 25°C, per 12V module



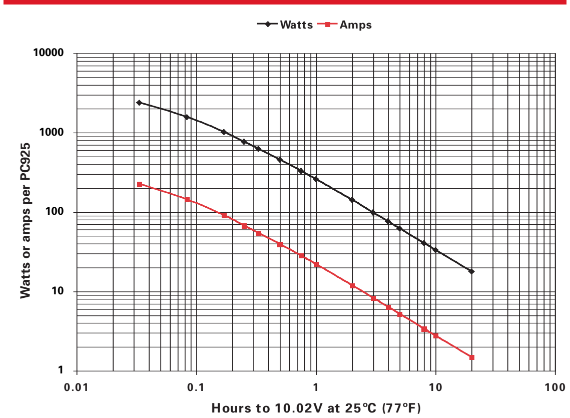
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/liter	Wh/liter	W/kg	Wh/kg
2 min	1486	143.0	4.8	49.5	601.4	20.0	212.3	7.1
5 min	792	78.8	6.6	66.0	320.5	26.7	113.1	9.4
10 min	512	49.3	8.4	87.1	207.3	35.25	73.2	12.4
15 min	389	36.7	9.2	97.4	157.6	39.4	55.6	13.9
20 min	318	29.6	9.8	104.9	128.7	42.5	45.4	15.0
30 min	236	21.6	10.8	118.2	95.7	47.8	33.8	16.9
45 min	173	15.6	11.7	130.1	70.2	52.6	24.8	18.6
1 hr	138	12.3	12.3	138.0	55.8	55.8	19.7	19.7
2 hr	79	6.9	13.8	157.2	31.8	63.6	11.2	22.5
3 hr	56	4.8	14.4	166.5	22.5	67.4	7.9	23.8
4 hr	43	3.7	14.8	172.8	17.5	69.9	6.2	24.7
5 hr	35	3.0	15.0	177.0	14.3	71.6	5.1	25.3
8 hr	23	2.0	16.0	187.2	9.5	75.75	3.3	26.7
10 hr	19	1.6	16.0	192.0	7.8	77.7	2.7	27.4
20 hr	10	0.8	16.0	204.0	4.1	82.6	1.5	29.1

PC680 performance data at 25°C, per 12V module

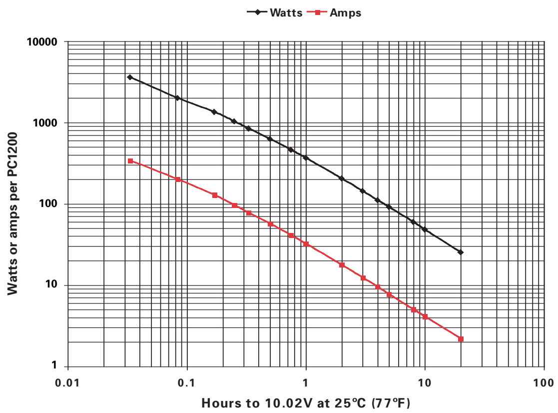


Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/liter	Wh/liter	W/kg	Wh/kg
2 min	2381	224.8	7.5	79.3	615.8	20.5	201.8	6.7
5 min	1446	142.8	11.9	120.5	374.0	31.2	122.5	10.2
10 min	954	90.6	15.4	162.2	246.75	42.0	80.9	13.7
15 min	726	67.4	16.9	181.5	187.8	46.9	61.5	15.4
20 min	592	54.2	17.9	195.2	153.0	50.5	50.1	16.5
30 min	436	39.2	19.6	217.8	112.7	56.3	36.9	18.5
45 min	316	28.1	21.1	236.7	81.6	61.2	26.75	20.1
1 hr	250	21.9	21.9	249.6	64.6	64.6	21.2	21.2
2 hr	138	11.9	23.8	276.0	35.7	71.4	11.7	23.4
3 hr	96	8.3	24.9	288.0	24.8	74.5	8.1	24.4
4 hr	74	6.4	25.6	297.6	19.2	77.0	6.3	25.2
5 hr	61	5.2	26.0	303.0	15.7	78.4	5.1	25.7
8 hr	40	3.4	27.2	316.8	10.2	81.9	3.4	26.9
10 hr	32	2.8	27.5	324.0	8.4	83.8	2.75	27.5
20 hr	17	1.5	30.0	348.0	4.5	90.0	1.5	29.5

PC925 performance data at 25°C, per 12V module

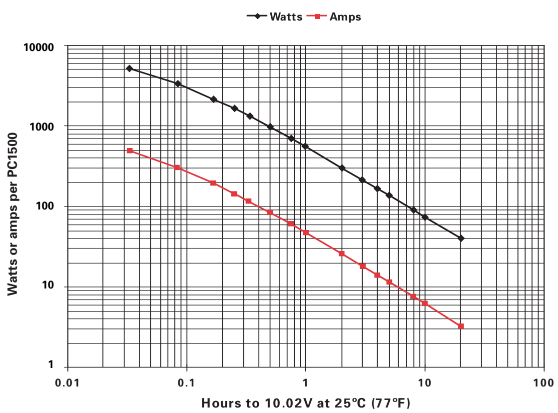


PC1200 performance data at 25°C, per 12V module



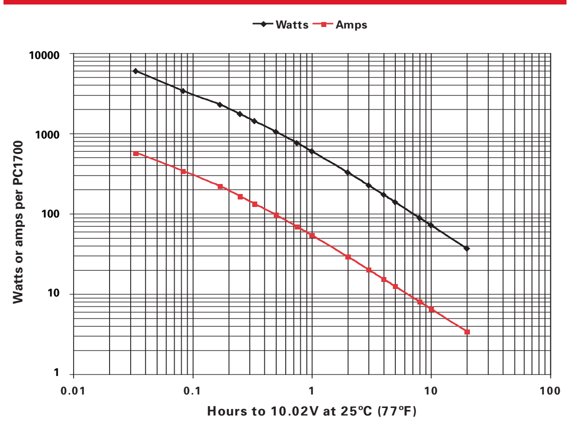
Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/liter	Wh/liter	W/kg	Wh/kg
2 min	3580	337.9	11.3	119.2	613.0	20.4	205.8	6.9
5 min	1992	199.1	16.6	165.9	341.1	28.4	114.5	9.5
10 min	1338	127.9	21.7	227.5	229.1	38.9	76.9	13.1
15 min	1026	96.0	24.0	256.5	175.7	43.9	59.0	14.7
20 min	840	77.5	25.6	277.2	143.8	47.5	48.3	15.9
30 min	624	56.6	28.3	312.0	106.8	53.4	35.9	17.9
45 min	458	40.8	30.6	343.4	78.4	58.8	26.3	19.7
1 hr	364	32.1	32.1	363.6	62.25	62.25	20.9	20.9
2 hr	203	17.7	35.4	406.8	34.8	69.7	11.7	23.4
3 hr	143	12.3	36.9	428.4	24.5	73.4	8.2	24.6
4 hr	110	9.5	38.0	441.6	18.9	75.6	6.3	25.4
5 hr	91	7.7	38.5	453.0	15.5	77.6	5.2	26.0
8 hr	59	5.0	40.0	475.2	10.2	81.4	3.4	27.3
10 hr	48	4.1	41.0	480.0	8.2	82.2	2.8	27.6
20 hr	25	2.2	44.0	504.0	4.3	86.3	1.5	29.0

PC1500 performance data at 25°C, per 12V module



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/liter	Wh/liter	W/kg	Wh/kg
2 min	5228	494.8	16.3	172.5	538.1	17.8	209.9	6.9
5 min	3337	304.4	25.3	277.0	343.5	28.5	134.0	11.1
10 min	2175	193.6	32.3	363.3	223.9	37.4	87.4	14.6
15 min	1644	144.5	36.1	411.0	169.2	42.3	66.0	16.5
20 min	1332	116.1	38.7	443.7	137.2	45.7	53.5	17.8
30 min	977	84.2	42.1	488.4	100.5	50.3	39.2	19.6
45 min	706	60.3	45.2	529.3	72.6	54.5	28.3	21.3
1 hr	556	47.3	47.3	556.2	57.3	57.3	22.3	22.3
2 hr	307	25.9	51.7	615.0	31.7	63.3	12.3	24.7
3 hr	215	18.1	54.2	646.5	22.2	66.5	8.7	26.0
4 hr	167	14.0	56.0	668.4	17.2	68.8	6.7	26.8
5 hr	137	11.5	57.4	685.4	14.1	70.6	5.5	27.5
8 hr	90	7.6	60.6	723.1	9.3	74.4	3.6	29.0
10 hr	74	6.2	62.3	742.5	7.6	76.4	3.0	29.8
20 hr	41	3.25	65.0	814.0	4.2	83.8	1.6	32.7

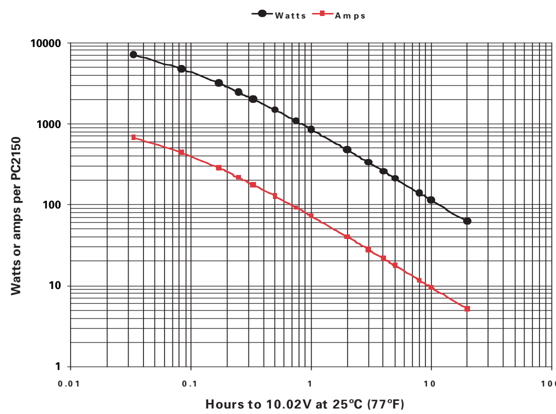
PC1700 performance data at 25°C, per 12V module



Time	Watts (W)	Amps (A)	Capacity (Ah)	Energy (Wh)	ENERGY AND POWER DENSITIES			
					W/liter	Wh/liter	W/kg	Wh/kg
2 min	5942	569.8	19.0	197.9	607.0	20.2	215.3	7.2
5 min	3636	337.6	28.1	279.9	343.3	28.6	121.7	10.1
10 min	2411	218.5	37.2	384.5	231.1	39.3	82.0	13.9
15 min	1833	163.8	41.0	433.5	177.2	44.3	62.8	15.7
20 min	1490	132.6	43.7	467.3	144.7	47.7	51.3	16.9
30 min	1091	96.0	48.0	522.0	106.7	53.3	37.8	18.9
45 min	786	68.6	51.4	567.0	77.2	57.9	27.4	20.5
1 hr	615	53.6	53.6	594.6	60.75	60.75	21.5	21.5
2 hr	333	28.9	57.8	648.0	33.1	66.2	11.7	23.5
3 hr	229	19.9	59.6	671.4	22.9	68.6	8.1	24.3
4 hr	175	15.2	61.0	684.0	17.5	69.9	6.2	24.8
5 hr	142	12.4	61.8	693.0	14.2	70.8	5.0	25.1
8 hr	90	8.0	63.6	705.6	9.0	72.1	3.2	25.6
10 hr	73	6.5	64.5	714.0	7.3	72.9	2.6	25.9
20 hr	37	3.4	67.9	732.0	3.7	74.8	1.3	26.5

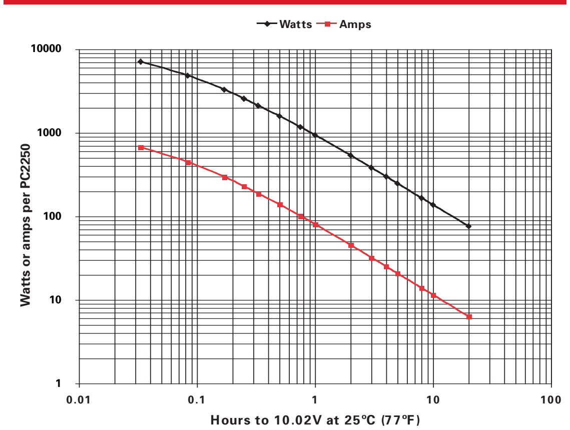
Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/liter	Wh/liter	W/kg	Wh/kg
2 min	7088	680.1	22.4	233.9	520.6	17.2	207.9	6.9
5 min	4755	438.1	36.4	394.7	349.2	29.0	139.4	11.6
10 min	3193	286.5	47.8	533.2	234.5	39.2	93.6	15.6
15 min	2448	216.7	54.2	611.9	179.7	44.9	71.8	17.9
20 min	2001	175.6	57.9	660.4	147.0	48.5	58.7	19.4
30 min	1482	128.6	64.3	741.2	108.9	54.4	43.5	21.7
45 min	1080	92.8	69.6	810.1	79.3	59.5	31.7	23.8
1 hr	855	73.0	73.0	855.5	62.8	62.8	25.1	25.1
2 hr	476	40.2	80.4	952.7	35.0	70.0	14.0	27.9
3 hr	334	28.1	84.2	1003.3	24.6	73.7	9.8	29.4
4 hr	259	21.7	86.8	1037.4	19.0	76.2	7.6	30.4
5 hr	213	17.8	88.9	1063.3	15.6	78.1	6.2	31.2
8 hr	140	11.7	93.3	1118.4	10.3	82.1	4.1	32.8
10 hr	115	9.6	95.5	1145.4	8.4	84.1	3.4	33.6
20 hr	62	5.2	104.0	1243.2	4.6	91.3	1.8	36.5

PC2150 performance data at 25°C, per 12V module



Time	Watts	Amps	Capacity	Energy	ENERGY AND POWER DENSITIES			
	(W)	(A)	(Ah)	(Wh)	W/liter	Wh/liter	W/kg	Wh/kg
2 min	7090	671.6	22.4	236.1	1143.0	14.75	181.8	6.1
5 min	4820	443.8	37.0	401.5	301.2	25.1	123.6	10.3
10 min	3291	296.4	50.4	559.5	205.6	35.0	84.4	14.4
15 min	2553	227.1	56.8	638.3	159.5	39.9	65.5	16.4
20 min	2107	185.8	61.3	695.3	131.7	43.5	54.0	17.8
30 min	1583	137.9	69.0	791.5	98.9	49.5	40.6	20.3
45 min	1170	100.9	75.7	877.5	73.1	54.8	30.0	22.5
1 hr	937	80.2	80.2	937.0	58.6	58.6	24.0	24.0
2 hr	536	45.2	90.4	1072.0	33.5	67.0	13.7	27.5
3 hr	382	32.0	96.0	1146.0	23.9	71.6	9.8	29.4
4 hr	299	25.0	100.0	1196.0	18.7	74.7	7.7	30.7
5 hr	247	20.6	103.0	1235.0	15.4	77.2	6.3	31.7
8 hr	165	13.8	110.4	1320.0	10.3	82.5	4.2	33.9
10 hr	137	11.4	114.0	1370.0	8.6	85.6	3.5	35.1
20 hr	76	6.3	126.0	1520.0	4.75	95.0	2.0	39.0

PC2250 performance data at 25°C, per 12V module



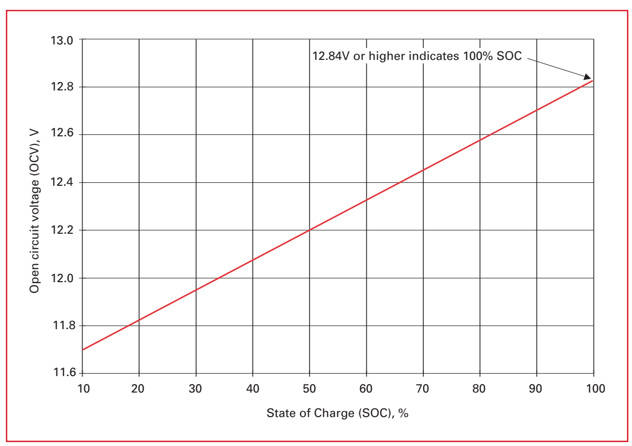
ODYSSEY storage and deep discharge recovery

For any rechargeable battery, storage and recharge are important criteria. This section provides some guidelines that will help you get the most from your ODYSSEY battery.

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

Use Figure 2 to determine the SOC of the ODYSSEY battery, as long as the battery has not been charged or discharged for six or more hours. The only tool needed is a good quality digital voltmeter to measure its open circuit voltage (OCV)[1]. The graph shows that a healthy, fully charged ODYSSEY battery will have an OCV of 12.84V or higher at 25°C (77°F)

Figure 2: Open circuit voltage and state of charge



[1] The OCV of a battery is the voltage measured between its positive and negative terminals without the battery connected to an external circuit (load). It is very important to take OCV reading only when the battery has been off charge for at least 6-8 hours, preferably overnight.

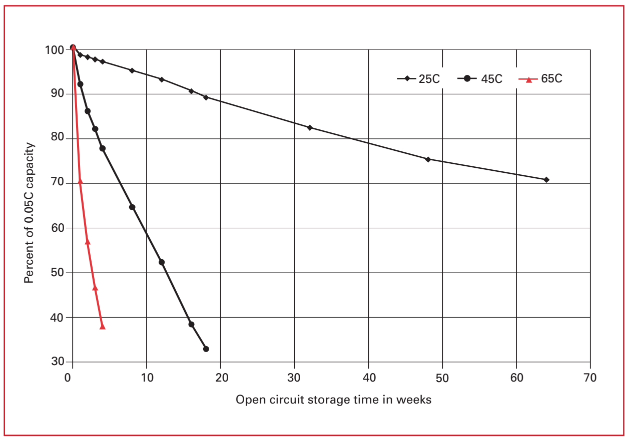
(B) How long can the battery be stored?

The graph below shows the shelf life of the ODYSSEY battery at different temperatures. At 25°C (77ºF), these batteries can be stored for up to 2 years. The lower the temperature, the longer the storage time. *Charge the battery before storing it.*

The effect of temperature on storage is evident. Roughly, every 10°C (18°F) increase in temperature cuts the storage time in half. Thus, at 35°C (95°F) the battery may be stored for only 1 year before a recharge becomes necessary.

Figure 3 applies only to batteries that are fully charged before storage.

Figure 3: ODYSSEY storage time at temperatures



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

Yes, the ODYSSEY battery can recover from extremely deep discharges as the following test results demonstrate.

(1) German DIN standard test for overdischarge recovery

In this test, a PC925 was discharged over 20 hours ($0.05C_{10}$ rate) to 10.20V. After the discharge[2] a 5Ω resistor was placed across the battery terminals and the battery kept in storage for 28 days.

At the end of the storage period, the battery was charged at 13.5V for only 48 hours. A second $0.05C_{10}$ discharge yielded 97% of rated capacity, indicating that a low rate 48-hour charge after such a deep discharge was insufficient; however, the intent of the test is to determine if the battery is recoverable 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.

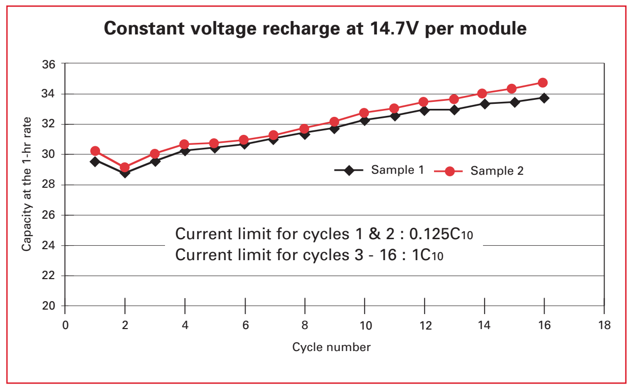
These test results prove that ODYSSEY batteries can recover from abusive storage conditions. Reinforcing this conclusion is the next test, which is even harsher than the DIN standard test, because in this test the battery was stored in a discharged state at a temperature of 50°C (122°F).

(2) High temperature discharged storage test

Two PC1200 samples were discharged in this test at the 1-hour rate to 9V per module, and then placed in storage at 50°C (122°F) in a *discharged condition* for 4 weeks.

At the end of 4 weeks, the two batteries were recharged using a constant voltage (CV) charge at 14.7V per battery. As Figure 4 below shows, both samples recovered from this extreme case of abusive storage.

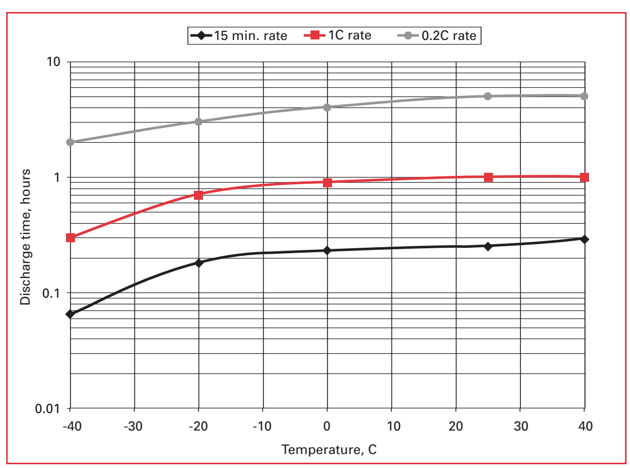
Figure 4: Recovery from high temperature discharged storage



Low temperature performance

Excellent low temperature performance is another feature that sets the ODYSSEY battery apart from the others. Figure 5 below shows that at -30ºC (-22ºF) the battery will deliver as much as 40% of its 15-minute rating.

Figure 5: ODYSSEY capacity at temperatures



[2] *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 PC925 would have a C_{10} rate of 2.6A.*

Parasitic loads

In more and more applications the phenomenon of parasitic loads is becoming a serious problem. Parasitic loads are small currents, typically a few milliamps (mA) that the battery continuously delivers for various reasons. Retaining memories and operating security systems are common examples of parasitic drains on batteries.

Even though the drain is low, the effect of a parasitic load on a long-term basis can be significant when the battery supports it 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 PC625, 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 37 days.

Because the ODYSSEY battery 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 2 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 the table 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 2: Effect of 18mA parasitic load on storage

	ODYSSEY PC model										
	310	535	545	625	680	925	1200	1500	1700	2150	2250
Days to 0% SOC	18	34	32	41	37	69	101	150	157	240	291
Days to 30% SOC	13	24	22	29	25	48	71	105	110	168	204

Table 2 shows how important it is to make sure your battery does not have a parasitic load; if there is a slow drain, connect the battery to a float (trickle) charger to compensate for capacity losses. Alternatively, physically disconnect one of the battery cables to eliminate the small drain.

Shock, impact and vibration testing

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 for installation on warships. A 26Ah battery (equivalent to the PC925 but without the metal jacket) was installed in an UPS system aboard a Navy MHC51-class coastal mine hunter.

The test is designed to simulate the shock generated by a 16" 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.

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

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

ODYSSEY 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 inches.

(C) Ford™ vehicle vibration test

Two batteries, equivalent to the PC925 and PC1200, were mounted in a special fixture and tested per the following parameters:

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 by an independent test facility. Two batteries, equivalent to the PC925 and PC1200, were mounted in a special fixture and tested in the following manner:

Test direction	Frequency Hz	Acceleration g	Duration min.
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 based on 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 is a very desirable feature in SLI batteries.

(E) Caterpillar 100-hour vibration test

In this test, a fully charged battery was vibrated at 34±1 Hz and 1.9 mm (0.075") total amplitude in a vertical direction, corresponding to an acceleration of 4.4g. The test was conducted for a total of 100 hours. The battery is considered to have passed the test if (a) it does not lose any electrolyte, (b) it is able to support a load test and (c) it does not leak when subjected to a pressure test.

The ODYSSEY battery successfully completed this arduous test.

(F) Shock and vibration test per IEC 61373, Sections 8-10

An independent test laboratory tested an ODYSSEY PC2150 battery for compliance to IEC standard 61373, Category 1, Class B, and Sections 8 through 10. Section 8 calls for a functional random vibration test, Section 9 requires a long-life random vibration test and Section 10 is for a shock test. Table 3 summarizes the test results.

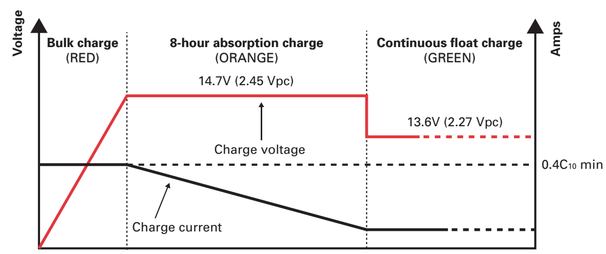
Table 3: Shock and vibration test results per IEC 61373

Test	Standard	Requirement	Result
Functional random vibration	IEC 61373, Section 8, Category 1, Class B	5-150Hz, 0.1g_{rms} vertical, 0.071g_{rms} longitudinal, 0.046g_{rms} transverse; 10 minutes in each axis	Compliant
Long-life random vibration	IEC 61373, Section 9, Category 1, Class B	5-150Hz, 0.8g_{rms} vertical, 0.56g_{rms} longitudinal, 0.36g_{rms} transverse; 5 hours in each axis	Compliant
Shock	IEC 61373, Section 10, Category 1, Class B	30msec. pulses in each axis (3 positive, 3 negative); 3.06g_{peak} vertical, 5.1g_{peak} longitudinal, 3.06g_{peak} transverse	Compliant

Charging ODYSSEY batteries

Charging is a key factor in the proper use of a rechargeable battery. Inadequate or improper charging is a common cause of premature failure of rechargeable lead acid batteries. To properly charge your premium ODYSSEY battery, EnerSys has developed a special charge algorithm. It is designed to rapidly and safely charge these batteries. Called the IUU profile (a constant current mode followed by two stages of constant voltage charge), Figure 6 shows it in a graphical format. No manual intervention is necessary with chargers having this profile.

Figure 6: Recommended three-step 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 ºC variation from 25ºC

If the charger has a timer, then it can switch from absorption mode to float mode when the current drops to $0.001C_{10}$ amps. If the current fails to drop to $0.001C_{10}$ amps, then the timer will force the transition to a float charge after no more than 8 hours. As an example, for a PC1200 battery, the threshold current should be 44mA. Another option is to let the battery stay in the absorption phase (14.7V or 2.45 VPC) for a fixed time, such as 6-8 hours, then switch to the continuous float charge. Table 3 shows three charger design variations, all based on the basic three-step profile shown in Figure 6.

Table 4: Three-step charger design options

	Charge Phase & Feature				
	Bulk charge	Absorption charge	Timer	Trigger current, A	Float charge
Design 1	Yes	Yes	Yes	$0.001C_{10}$	Yes
Design 2	Yes	Yes	Yes	No trigger	Yes
Design 3	Yes	Yes	No	$0.10C_{10}$	Yes

In Design 1, the charger has a timer and a current threshold that triggers the switch from absorption charge to float charge. Because the charger has a timer override, the charge current is set at a low value. If the charge current does not drop to $0.001C_{10}$ amps within 8 hours on absorption charge, then the timer will force the charger to switch to a temperature-compensated float charge.

The charger does not have a current trigger in Design 2. Rather, the timer forces the charger to stay in the absorption phase for a fixed time (8 hours) before allowing it to switch down to a temperature-compensated float charge.

Because the charger in Design 3 does not have a timer, the threshold current to trigger the switch from the absorption phase to the temperature-compensated float charge phase is kept relatively high. Note that in this design the battery will not be fully charged when the charger switches to the float charge phase. *A minimum of 16-24 hours on float will be required to complete the charge.*

Table 5 shows the minimum charge currents for the full range of ODYSSEY batteries. When using a charger with the IUU profile, we suggest the following ratings for your ODYSSEY battery. *Note the charger current in the bulk charge mode must be $0.4C_{10}$ or more.* A list of chargers approved by EnerSys for use with ODYSSEY batteries is available at http://www.odysseyfactory.com/odycharg_c.htm.

Table 5: Battery size and minimum three-step charger current

Charger rating, amps	Recommended ODYSSEY model
6A	PC310 / PC535 / PC545 / PC625 / PC680
10A	PC925 or smaller battery
15A	PC1200 or smaller battery
25A	PC1500 or smaller battery
25A	PC1700 or smaller battery
40A	PC2150 or smaller battery
50A	PC2250 or smaller battery

Small, portable automotive and powersport chargers may also be used to charge your ODYSSEY battery. These chargers are generally designed to bring a discharged battery to a state of charge (SOC) that is high enough to crank an engine. Once the engine is successfully cranked its alternator should fully charge the battery. It is important to keep in mind the design limitations of these small chargers when using them.

Another class of chargers is designed specifically to maintain a battery in a high SOC. These chargers, normally in the $^3/_4$ amp to $1^1/_2$ amp range, are not big enough to charge a deeply discharged ODYSSEY battery. They must only be used either to continuously compensate for parasitic losses or to maintain a trickle charge on a stored battery, as long as the correct voltages are applied. It is very important, 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

Qualifying portable automotive and powersport 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, then 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 14.7V, then immediately shuts off. An example of the second type of automatic charger would bring the battery up to 14.7V, then switches to a float (trickle) voltage of 13.6V; it will stay at that level indefinitely. The second type of automatic charger is preferred, because the first type of charger will undercharge the battery.

A manual charger typically puts out either a single voltage or single current level continuously and must be switched off manually to prevent battery overcharge. *Should you choose to use a manual charger with your ODYSSEY battery, do not exceed charge times suggested in Table 6 below. It is extremely important to ensure the charge voltage does not exceed 15V.*

(B) Selecting battery type on your charger

Although it is not possible to cover every type of battery charger available today, this section gives 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 or AGM option, should there be one on your charger. Table 6 below gives suggested charge times based on charger currents. *To achieve maximum life from your ODYSSEY battery after completing the charge time in Table 6, we recommend that you switch your charger to the 2A trickle charge position and leave the battery connected to the charger for an additional 6-8 hours. The trickle charge voltage should be 13.5V to 13.8V.*

Table 6: Suggested charge times

	Charge time for 100% discharged battery	
Model	**10A charger**	**20A charger**
PC310	1 hr.	30 min.
PC535	1 1/2 hr.	45 min.
PC545	1 1/2 hr.	45 min.
PC625	2 hr.	1 hr.
PC680	2 hr.	1 hr.
PC925	2 1/2 hr.	1 1/4 hr.
PC1200	4 hr.	2 hr.
PC1500	5 hr.	2 1/2 hr.
PC1700	7 hr.	3 1/2 hr.
PC2150	9 hr.	4 1/2 hr.
PC2250	11 hr.	5 1/2 hr.

The charge times recommended in Table 6 assume that the ODYSSEY battery is fully discharged and these charge times will only achieve a 90% state of charge. For partially discharged batteries, the charge times should be appropriately reduced. The graph in Figure 2, showing OCV and SOC, must be used to determine the battery's SOC. The battery should be trickle charged (2A setting) after high rate charging, regardless of its initial SOC.

Rapid charging of ODYSSEY batteries

All ODYSSEY batteries can be quickly charged. The graph below shows their exceptional fast charge characteristics at a constant 14.7V for three levels of inrush current. These current levels are similar to the output currents of modern automotive alternators. Table 7 and Figure 7 show the capacity returned as a function of the magnitude of the inrush[3] current.

Standard internal combustion engine alternators with an output voltage of 14.2V can also charge these batteries. The inrush current does not need to be limited under constant voltage charge. However, because the typical alternator voltage is only 14.2V instead of 14.7V, the charge times will be longer than those shown in Table 6.

Table 7: Fast charge capability

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.

Figure 7: Quick charging ODYSSEY batteries

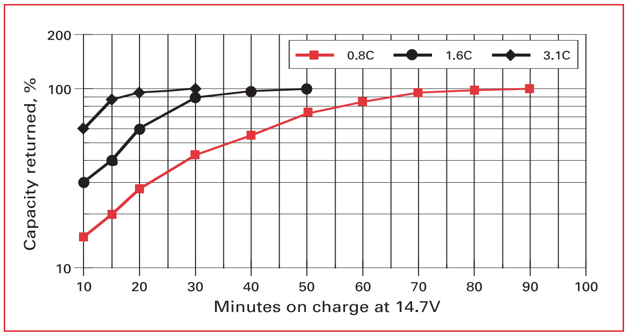


Table 7 shows that with a $0.8C_{10}$ inrush current, a 100% discharged battery can have 80% of its capacity returned in 57 minutes; doubling the inrush to $1.6C_{10}$ cuts the time taken to reach 80% capacity to only 28 minutes.

Concluding remarks

We believe that there is no other sealed-lead acid 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.

[3] Inrush is defined in terms of the rated capacity (C_{10}) of the battery. A $0.8C_{10}$ inrush on a 100Ah battery is 80A.

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 deliver for 30 seconds at a temperature of -18°C (0°F) before the voltage drops to 1.20 volts per cell, or 7.20 volts for a 12V battery. A 12V battery that has a rating of 550 CCA means that the battery will provide 550 amps for 30 seconds at -18°C (0°F) before the voltage falls to 7.20V.

What is the MCA rating?

The marine cranking ampere (MCA) rating refers to the number of amperes a battery can deliver for 30 seconds at a temperature of 0°C (32°F) until the battery voltage drops to 7.20 volts for a 12V battery. A 12V battery that has a MCA rating of 725 MCA means that the battery will give 725 amperes for 30 seconds at 0°C (32°F) 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 26.7°C (80°F).

What is the PHCA rating?

Unlike CCA and MCA the pulse hot cranking amp (PHCA) rating does not have an "official" definition; however, we believe that for true SLI purposes, a 30-second discharge is unrealistic. The PHCA, a short duration (about 3-5 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?

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

What is the difference between gel cell and AGM?

The key difference between the gel cell and the absorbed glass mat (AGM) is that in the AGM cell all the electrolyte is in the separator, whereas in the gel cell the acid is in the cells in a gel form. If the ODYSSEY battery were to split open, there would be no acid spillage! That is why we call the ODYSSEY a Drycell™ battery

What is the Ah rating?

The ampere-hour (Ah) rating defines the capacity of a battery. A battery rated at 100Ah at the 10-hour rate of discharge will deliver 10A for 10 hours before the terminal voltage drops to a standard value such as 10.02 volts for a 12V battery. The PC1200 battery, rated at 40Ah will deliver 4A 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 27°C (80°F) before its voltage drops to 10.50 volts for a 12V battery. A 12V battery with a reserve capacity rating of 100 will deliver 25 amps for 100 minutes at 80°F before its voltage drops to 10.5V.

Is the 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 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.

What is the short-circuit current of these batteries?

As mentioned before, this battery has very low impedance, meaning that the short circuit current is very high. For a PC925 battery, the short circuit current can be as high as 2,500 amperes.

Do I ruin the battery if I accidentally drop it?

Not necessarily, but it is possible to damage the internal connections sufficiently to damage the battery.

Does mishandling the battery void the warranty?

Our warranty applies only to manufacturing defects and workmanship issues; the policy does not cover damages suffered due to product mishandling.

What is so special about thin plate pure lead 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 automotive engine to ensure its reliability during the winter season. The procedure essentially checks the engine's charging system; in addition, the battery is load tested according to a specific method defined by the Battery Council International (BCI). Although 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 as a Ni-Cd?

No, the ODYSSEY is NOT a Ni-Cd battery. It is a valve regulated lead acid (VRLA) 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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