LEAD-X

Advanced Technology, Pure Lead-Tin, High Energy Density
VRLA Battery

Technical Manual

HBL™

Pure Lead-Tin Technology

Pure Lead-Tin technology offers many advantages which include:

- High overall efficiency
- High energy density
- Excellent high rate performance
- Excellent low temperature performance
- Long float life
- High cycle life

The technology enables continuous manufacture of thin plates using automated assembly lines complete with sophisticated equipment and online quality checks.

A battery is a critical component of any power supply system and has a significant impact on its performance and reliability. Today, there is a distinct preference for high-performance, compact and light weight batteries.

Engineered by HBL, Lead-X redefines performance. Lead-X batteries employ Pure Lead-Tin, thin plate design for high performance. These Valve Regulated Lead Acid (VRLA) batteries are designed using Absorbent Glass Mat (AGM) separators that render the batteries spill-proof. Use of AGM separators in combination with self-resealing, pressure regulating valves and a starved electrolyte design enable recombination of gasses generated during normal operation. This eliminates the need for electrolyte top-up.

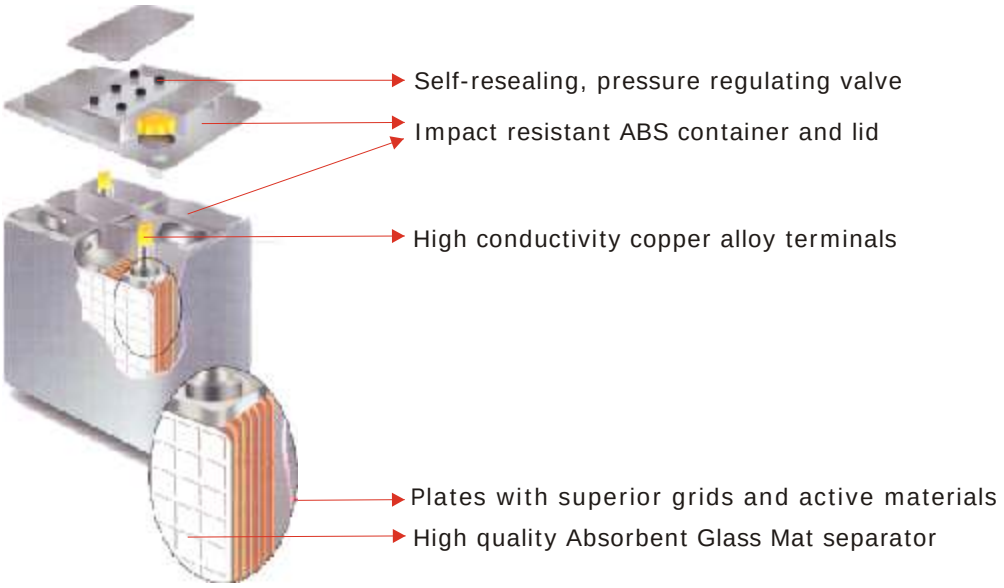
Lead-X batteries are delivered fully charged and can be commissioned immediately without delay.

Superior Features

- Maintenance-free and spill-proof. This enables flexible mounting
- Compact and light weight for easy handling
- Wide operating temperature range (-40ºC to +50ºC)
- High energy density (gravimetric and volumetric)
- Good charge retention leading to long storage life
- Low internal resistance ensures quick recharge
- Excellent high rate capability permits use of smaller capacity batteries
- Superior raw materials for good performance and life
- Excellent deep discharge recovery characteristics
- UL recognized plastic components

Lead - X batteries conforms to IEC 60896 - 21 & 22 : 2004 and are certified by Intertek ETL SEMKO.

Construction



Applications

Lead X batteries are the ideal choice for all applications requiring reliable back-up. Typical applications include

- Telecommunications / Standby power
- Cycle Duty
- UPS

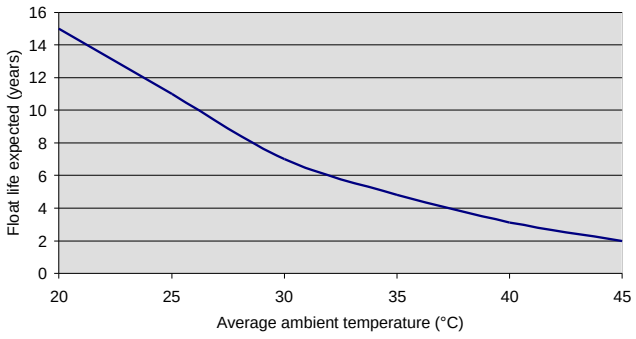
Float Life

In a float arrangement, the battery is kept connected across a charger which continually replenishes the drain in the battery caused due to self-discharge.

The expected life of a battery, also known as its designed life, is influenced by the ambient temperature. Based on the Arrhenius Equation, which relates ambient temperature and the rate of positive-grid corrosion of the battery, it is estimated that the expected life of lead acid batteries is reduced by 50% for every 8 to 10°C rise in the average ambient temperature.

The expected float life of batteries at various average ambient temperatures, when floated at a float voltage of 2.25 volts per cell, is shown in Graph1.

Graph 1 - Float life Vs Average temperature



When a lead acid battery reaches the end of its life, the failure mode is positive grid corrosion. Grid corrosion reduces the available cross section of the grid which is required to carry current. While this reduced cross section is adequate to deliver low currents while carrying out capacity tests, it is not adequate to sustain high currents.

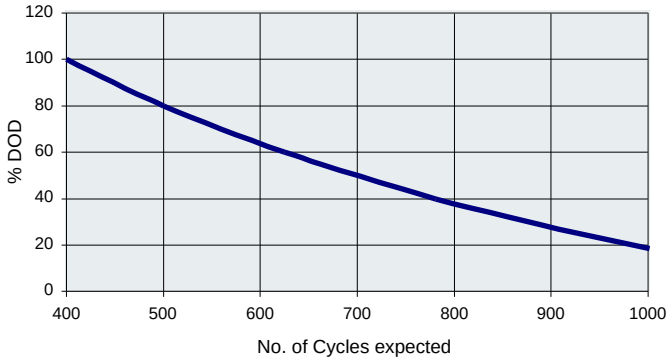
The special Pure Lead-Tin alloy minimizes positive grid corrosion.

Cycle Life

An alternative method of expressing battery life is the number of cycles that can be delivered by a battery at a specified discharge rate to a specified end voltage at an ambient temperature of 25ºC.

The depth of discharge (DOD) is an important variable affecting the battery's cycle life expectancy (as shown in Graph 2 below). It is important to optimize the charging regime of the battery for cycling applications in order to ensure full recharge before discharging the battery. Full recharge can be achieved by using an elevated voltage for charging. It is highly detrimental to subject an undercharged battery to cycling since this will cause premature battery failure.

Graph 2 - Cycle Life Vs Depth of Discharge



Charging

Constant voltage charging is the most preferred charging method for Lead-X batteries.

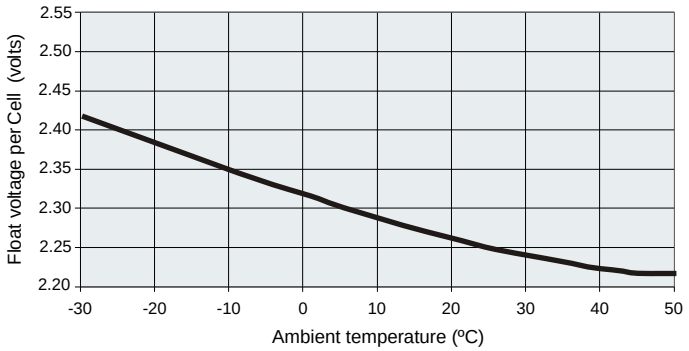
When charging the battery with a constant voltage charger in float applications, the charger must be set at the following voltages at 25°C. Boost: 2.4V per cell , Float: 2.25V per cell.

For cyclic applications, where the time available for re-charging is limited, rapid charging can be carried out at the boost voltage specified above.

No current limit is required during constant voltage charging. However, the charger should be capable of giving at least $0.1C_{10}$ A (where C_{10} is the capacity of battery at 10 hr rate of discharge to end 1.80V per cell). The charger should automatically sense the current drawn by the battery and switch over to the float mode when the battery is fully charged.

The charger should provide temperature compensation (as shown in Graph 3) to ensure optimum charging of the battery. The charger should also have an AC voltage ripple of <3% RMS.

Graph 3 - Temperature Compensation



Battery housing and ventilation

Lead-X batteries can be installed in cabinets or enclosures with a gap of 10 to 15 mm in between batteries and with a free space of minimum 100 mm on top of terminals for the accessibility of installation and maintenance.

The gassing evolved during normal float charging will be negligible. The cabinet must have an air circulation to limit the hydrogen gas accumulation to less than 1% during the boost charging of the battery to comply with the requirements of EN 50272 Part-2.

The charger must have temperature compensation to regulate the charge input at different ambient temperatures and the thermal sensor should sense the battery temperature. When the batteries are installed in a closed cabinet, the temperature will rise during charging. Forced air circulation by means of fans (or by any other means) must be provided to dissipate the heat and maintain the temperature within 5°C above ambient.

Storage

Batteries lose capacity when not in use, a phenomenon termed as self-discharge. The use of pure raw materials decreases the rate of self-discharge and enhances storage life. Loss of capacity during storage is to be compensated for by giving a freshening charge to the battery. In case the batteries are stored for very long periods or at high temperatures without giving a freshening charge, there will be an irreversible sulphation leading to permanent loss in capacity.

Lead-X batteries can be stored for a maximum period of two years at 20ºC with open circuit voltage (OCV) monitoring every 4 months. If the OCV falls to 2.1V per cell, the battery should be given a freshening charge at 2.4V per cell for 12hrs. OCV Monitoring interval with respect to temperature of storage is given in Table 1 below.

Table 1

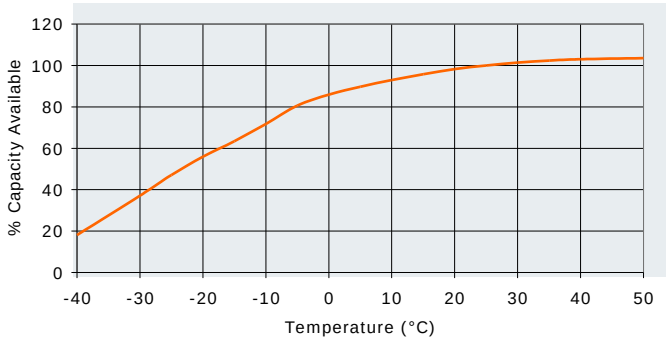
Temperature (ºC)	Monitoring Frequency (months)
< 20	6
20 – 29	4
30 – 35	3
36 – 40	2
41 – 50	1

Discharge Performance

Lead-X batteries are rated at the 10hr rate of discharge to end 1.80 V per cell at 25ºC. Discharge currents and power available at 25ºC from these batteries for different time periods and to different end voltages is given in this manual.

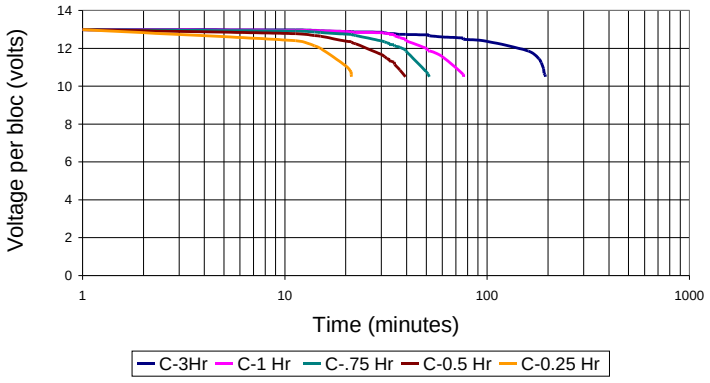
These batteries are capable of performing between -40ºC and +50ºC. The performance of the battery will however be reduced at low temperatures (see Graph 4). At higher temperatures, the performance will be enhanced, but the life of battery is reduced.

Graph 4 - Capacity available at different temperatures
(% of rated 10 hr capacity)

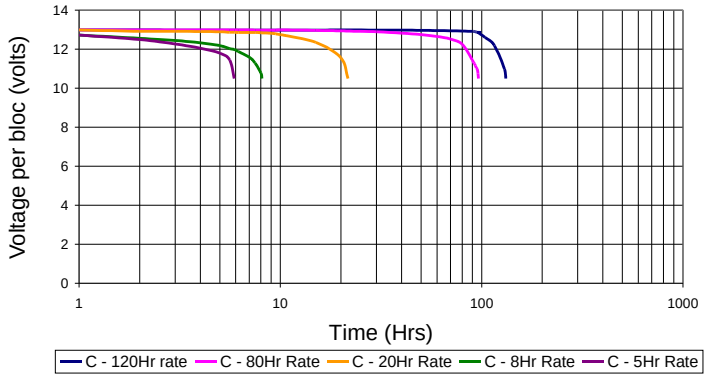


These batteries can be used for applications with back-up duration of as short as 5 minutes (high rate discharge) to as long as 120 hours (low rate discharge). Discharge graphs (Graph 5 and Graph 6) at various rates of discharge for these batteries are given below:

Graph 5 - Voltage Vs Time



Graph 6 - Voltage Vs Time



Range of 12V Monoblocs

Model	Capacity C_{10}, 1.80 (Ah)	Dimensions (mm) L	W	H	Approx.Wt. (kgs)	Terminal
LX-12 13	13	175	85	130	5	M6 (F)
LX-12 16	16	181	76	168	6	M6 (F)
LX-12 20	20	163	142	147	9	M6 (F)
LX-12 24	24	249	97	151	10	M6 (F)
LX-12 25	25	175	166	125	11	Ø6
LX-12 30	30	163	142	200	12	M6 (F)
LX-12 37	37	249	97	201	13	M6 (F)
LX-12 40	40	197	165	170	15	M8 (F)
LX-12 50	50	220	121	260	19	M6 (F)
LX-12 70	70	330	168	176	23	M6 (F)
LX-12 80	80	286	268	182	32	M8 (F)
LX-12 100	100	410	175	225	36	M8 (F)
LX-12 120	120	525	220	225	48	M8 (F)
LX-12 150	150	525	220	225	56	M8 (F)

Range of 6V Monoblocs

Model	Capacity C_{10}, 1.80 (Ah)	Dimensions (mm) L	W	H	Approx.Wt. (kgs)	Terminal
LX-6 115	115	205	197	235	23	M8 (F)
LX-6 136	136	205	197	235	25	M8 (F)

Nominal capacity is at 10 hour rate of discharge to 1.80 Vpc at 25° C

Constant Current Performance at 25ºC

End Voltage 1.60 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	58	36.3	27.6	21.0	16.1	12.0	9.6	5.4	3.78	2.90	2.44	2.09	1.80	1.58	1.45	1.41	0.75
LX-12 16	71	44.5	33.8	25.8	19.8	14.7	11.7	6.6	4.63	3.56	2.99	2.56	2.21	1.94	1.78	1.73	0.92
LX-12 20	90	56	42.6	32.5	24.9	18.5	14.8	8.4	5.8	4.49	3.77	3.23	2.78	2.45	2.24	2.18	1.16
LX-12 24	108	67	51	38.9	29.9	22.2	17.7	10.0	7.0	5.4	4.52	3.87	3.33	2.93	2.69	2.61	1.39
LX-12 25	112	70	53	40.3	31.0	23.0	18.4	10.4	7.3	5.6	4.68	4.01	3.45	3.04	2.78	2.70	1.44
LX-12 30	134	84	64	48.5	37.2	27.6	22.1	12.5	8.7	6.7	5.6	4.81	4.15	3.65	3.34	3.25	1.73
LX-12 34	152	104	79	60	46.0	34.1	27.3	15.4	10.8	8.3	7.0	6.0	5.13	4.52	4.14	4.02	2.14
LX-12 40	179	112	85	65	49.7	36.8	29.5	16.6	11.6	8.9	7.5	6.4	5.5	4.88	4.46	4.33	2.31
LX-12 50	224	140	106	81	62	46.1	36.8	20.8	14.6	11.2	9.4	8.0	6.9	6.1	5.6	5.4	2.89
LX-12 70	314	195	148	113	87	64	52	29.1	20.3	15.6	13.1	11.2	9.7	8.5	7.8	7.6	4.04
LX-12 80	359	224	170	129	99	74	59	33.3	23.3	17.9	15.0	12.9	11.1	9.8	8.9	8.7	4.62
LX-12 100	449	280	212	162	124	92	74	41.6	29.1	22.4	18.8	16.1	13.9	12.2	11.2	10.8	5.8
LX-12 120	538	335	255	194	149	110	88	49.9	34.9	26.8	22.5	19.3	16.6	14.6	13.4	13.0	6.9
LX-12 150	673	420	319	243	186	138	111	62	43.7	33.6	28.2	24.1	20.8	18.3	16.8	16.3	8.7
LX-6 115	515	321	244	186	143	106	85	47.8	33.4	25.7	21.6	18.5	15.9	14.0	12.8	12.5	6.6
LX-6 136	610	380	289	220	169	125	100	57	39.6	30.4	25.5	21.9	18.9	16.6	15.2	14.7	7.9

End Voltage 1.63 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	58	36.1	27.4	20.9	16.0	11.9	9.5	5.4	3.75	2.88	2.42	2.07	1.79	1.57	1.44	1.40	0.75
LX-12 16	71	44.3	33.6	25.6	19.7	14.6	11.7	6.6	4.61	3.54	2.97	2.55	2.19	1.93	1.77	1.72	0.92
LX-12 20	89	55	42.1	32.1	24.6	18.3	14.6	8.2	5.8	4.43	3.72	3.19	2.75	2.42	2.21	2.15	1.15
LX-12 24	107	67	51	38.5	29.6	21.9	17.5	9.9	6.9	5.3	4.47	3.83	3.30	2.90	2.66	2.58	1.38
LX-12 25	111	69	53	40.1	30.7	22.8	18.2	10.3	7.2	5.5	4.65	3.98	3.43	3.02	2.76	2.68	1.43
LX-12 30	133	83	63	48.0	36.9	27.3	21.9	12.3	8.6	6.6	5.6	4.77	4.11	3.62	3.31	3.22	1.72
LX-12 34	158	103	78	59	45.6	33.8	27.0	15.3	10.7	8.2	6.9	5.9	5.09	4.48	4.10	3.98	2.12
LX-12 40	178	111	84	64	49.2	36.5	29.2	16.5	11.5	8.9	7.4	6.4	5.5	4.83	4.42	4.30	2.29
LX-12 50	222	138	105	80	61	45.6	36.5	20.6	14.4	11.1	9.3	8.0	6.9	6.0	5.5	5.4	2.86
LX-12 70	311	194	147	112	86	64	51	28.8	20.2	15.5	13.0	11.1	9.6	8.5	7.7	7.5	4.01
LX-12 80	355	221	168	128	98	73	58	32.9	23.0	17.7	14.9	12.7	11.0	9.7	8.8	8.6	4.58
LX-12 100	445	277	210	160	123	91	73	41.2	28.8	22.2	18.6	15.9	13.7	12.1	11.1	10.7	5.7
LX-12 120	533	332	252	192	148	109	88	49.4	34.6	26.6	22.3	19.1	16.5	14.5	13.3	12.9	6.9
LX-12 150	666	415	316	240	185	137	109	62	43.2	33.2	27.9	23.9	20.6	18.1	16.6	16.1	8.6
LX-6 115	511	318	242	184	141	105	84	47.4	33.1	25.5	21.4	18.3	15.8	13.9	12.7	12.3	6.6
LX-6 136	604	377	286	218	167	124	99	56	39.2	30.1	25.3	21.7	18.7	16.4	15.0	14.6	7.8

End Voltage 1.67 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	57	35.8	27.2	20.7	15.9	11.8	9.4	5.3	3.73	2.86	2.41	2.06	1.78	1.56	1.43	1.39	0.74
LX-12 16	71	44.0	33.4	25.5	19.6	14.5	11.6	6.6	4.58	3.52	2.96	2.53	2.18	1.92	1.76	1.71	0.91
LX-12 20	88	55	41.5	31.6	24.3	18.0	14.4	8.1	5.7	4.37	3.67	3.14	2.71	2.39	2.18	2.12	1.13
LX-12 24	106	66	50	38.1	29.2	21.7	17.3	9.8	6.8	5.3	4.42	3.78	3.26	2.87	2.63	2.55	1.36
LX-12 25	110	69	52	39.8	30.5	22.6	18.1	10.2	7.2	5.5	4.62	3.95	3.41	3.00	2.74	2.66	1.42
LX-12 30	132	82	62	47.6	36.6	27.1	21.7	12.2	8.6	6.6	5.5	4.73	4.08	3.59	3.28	3.19	1.70
LX-12 34	163	102	77	59	45.2	33.5	26.8	15.1	10.6	8.1	6.8	5.8	5.04	4.43	4.06	3.94	2.10
LX-12 40	176	110	83	64	48.8	36.2	28.9	16.3	11.4	8.8	7.4	6.3	5.4	4.79	4.39	4.26	2.27
LX-12 50	220	137	104	79	61	45.1	36.1	20.4	14.3	11.0	9.2	7.9	6.8	6.0	5.5	5.3	2.83
LX-12 70	308	192	146	111	85	63	51	28.6	20.0	15.4	12.9	11.0	9.5	8.4	7.7	7.4	3.97
LX-12 80	352	219	166	127	97	72	58	32.6	22.8	17.5	14.7	12.6	10.9	9.6	8.8	8.5	4.53
LX-12 100	440	274	208	159	122	90	72	40.8	28.6	21.9	18.4	15.8	13.6	12.0	11.0	10.6	5.7
LX-12 120	528	329	250	190	146	108	87	49.0	34.2	26.3	22.1	18.9	16.3	14.4	13.1	12.8	6.8
LX-12 150	660	411	312	238	183	136	108	61	42.8	32.9	27.6	23.7	20.4	17.9	16.4	16.0	8.5
LX-6 115	506	316	240	183	140	104	83	46.9	32.8	25.2	21.2	18.1	15.6	13.8	12.6	12.2	6.5
LX-6 136	598	373	283	216	166	123	98	56	38.8	29.8	25.1	21.5	18.5	16.3	14.9	14.5	7.7

Constant Current Performance at 25ºC

End Voltage 1.70 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	56	34.8	26.5	20.2	15.5	11.5	9.2	5.2	3.63	2.79	2.34	2.00	1.73	1.52	1.39	1.35	0.72
LX-12 16	69	43.1	32.7	24.9	19.1	14.2	11.3	6.4	4.48	3.44	2.89	2.48	2.13	1.88	1.72	1.67	0.89
LX-12 20	86	54	40.8	31.1	23.9	17.7	14.2	8.0	5.6	4.30	3.61	3.09	2.66	2.34	2.14	2.08	1.11
LX-12 24	103	64	48.9	37.3	28.6	21.2	17.0	9.6	6.7	5.1	4.32	3.70	3.19	2.81	2.57	2.50	1.33
LX-12 25	108	67	51	38.9	29.9	22.2	17.7	10.0	7.0	5.4	4.52	3.87	3.33	2.93	2.69	2.61	1.39
LX-12 30	130	81	61	46.8	35.9	26.6	21.3	12.0	8.4	6.5	5.4	4.65	4.01	3.53	3.23	3.13	1.67
LX-12 34	160	100	76	58	44.3	32.8	26.3	14.8	10.4	8.0	6.7	5.7	4.94	4.35	3.98	3.87	2.06
LX-12 40	172	107	82	62	47.7	35.4	28.3	16.0	11.2	8.6	7.2	6.2	5.3	4.69	4.29	4.17	2.22
LX-12 50	216	135	102	78	60	44.3	35.4	20.0	14.0	10.8	9.0	7.7	6.7	5.9	5.4	5.2	2.78
LX-12 70	302	188	143	109	84	62	49.6	28.0	19.6	15.1	12.6	10.8	9.3	8.2	7.5	7.3	3.89
LX-12 80	345	215	164	125	96	71	57	32.0	22.4	17.2	14.5	12.4	10.7	9.4	8.6	8.4	4.45
LX-12 100	432	269	204	156	120	89	71	40.0	28.0	21.5	18.1	15.5	13.3	11.7	10.7	10.4	5.6
LX-12 120	518	323	245	187	143	106	85	48.0	33.6	25.8	21.7	18.6	16.0	14.1	12.9	12.5	6.7
LX-12 150	647	404	307	234	179	133	106	60	42.0	32.3	27.1	23.2	20.0	17.6	16.1	15.7	8.3
LX-6 115	496	309	235	179	137	102	81	46.0	32.2	24.7	20.8	17.8	15.3	13.5	12.3	12.0	6.4
LX-6 136	587	366	278	212	163	121	96	54	38.1	29.3	24.6	21.0	18.1	16.0	14.6	14.2	7.6

End Voltage 1.75 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	55	34.4	26.1	19.9	15.3	11.3	9.1	5.1	3.58	2.75	2.31	1.98	1.70	1.50	1.37	1.33	0.69
LX-12 16	68	42.4	32.2	24.5	18.8	14.0	11.2	6.3	4.41	3.39	2.84	2.44	2.10	1.85	1.69	1.64	0.85
LX-12 20	85	53	40.1	30.6	23.5	17.4	13.9	7.9	5.5	4.22	3.55	3.04	2.62	2.30	2.11	2.04	1.06
LX-12 24	102	63	48.1	36.6	28.1	20.9	16.7	9.4	6.6	5.1	4.25	3.64	3.14	2.76	2.53	2.45	1.27
LX-12 25	106	66	50	38.1	29.2	21.7	17.3	9.8	6.8	5.3	4.42	3.78	3.26	2.87	2.63	2.54	1.32
LX-12 30	127	79	60	45.9	35.2	26.1	20.9	11.8	8.2	6.3	5.3	4.56	3.93	3.46	3.16	3.06	1.59
LX-12 34	157	98	74	57	43.4	32.2	25.7	14.5	10.2	7.8	6.6	5.6	4.84	4.26	3.90	3.77	1.96
LX-12 40	169	106	80	61	46.9	34.8	27.8	15.7	11.0	8.4	7.1	6.1	5.2	4.61	4.22	4.08	2.12
LX-12 50	212	132	100	76	59	43.5	34.8	19.6	13.7	10.6	8.9	7.6	6.5	5.8	5.3	5.1	2.65
LX-12 70	297	185	140	107	82	61	48.7	27.5	19.2	14.8	12.4	10.6	9.2	8.1	7.4	7.1	3.71
LX-12 80	338	211	160	122	94	69	56	31.4	21.9	16.9	14.2	12.1	10.4	9.2	8.4	8.1	4.23
LX-12 100	423	264	200	153	117	87	69	39.2	27.4	21.1	17.7	15.2	13.1	11.5	10.5	10.2	5.3
LX-12 120	508	316	240	183	141	104	83	47.1	32.9	25.3	21.2	18.2	15.7	13.8	12.6	12.2	6.4
LX-12 150	635	396	300	229	176	130	104	59	41.2	31.6	26.6	22.7	19.6	17.3	15.8	15.3	7.9
LX-6 115	487	303	230	176	135	100	80	45	31.6	24.3	20.4	17.4	15.0	13.2	12.1	11.7	6.1
LX-6 136	575	359	272	208	159	118	95	53	37.3	28.7	24.1	20.6	17.8	15.6	14.3	13.9	7.2

End Voltage 1.80 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	52	32.7	24.8	18.9	14.5	11.1	8.9	5.0	3.52	2.70	2.27	1.95	1.68	1.48	1.35	1.30	0.68
LX-12 16	64	39.9	30.3	23.1	17.7	13.6	10.9	6.1	4.30	3.30	2.77	2.37	2.04	1.80	1.65	1.60	0.83
LX-12 20	80	50	38.0	28.9	22.2	17.1	13.6	7.7	5.4	4.14	3.47	2.98	2.56	2.26	2.07	2.00	1.04
LX-12 24	96	60	45.7	34.8	26.7	20.5	16.4	9.2	6.5	4.97	4.17	3.58	3.08	2.71	2.48	2.40	1.25
LX-12 25	100	63	47.5	36.2	27.8	21.3	17.0	9.6	6.7	5.2	4.34	3.72	3.20	2.82	2.58	2.50	1.30
LX-12 30	120	75	57	43.4	33.3	25.6	20.4	11.5	8.1	6.2	5.2	4.46	3.84	3.38	3.10	3.00	1.56
LX-12 34	148	92	70	53.5	41.1	31.5	25.2	14.2	10.0	7.6	6.4	5.5	4.74	4.17	3.82	3.70	1.92
LX-12 40	160	100	76	58	44.4	34.1	27.3	15.4	10.8	8.3	6.9	6.0	5.1	4.51	4.13	4.0	2.08
LX-12 50	200	125	95	72	56	42.6	34.1	19.2	13.5	10.3	8.7	7.4	6.4	5.6	5.2	5.0	2.60
LX-12 70	281	175	133	101	78	60	47.7	26.9	18.9	14.5	12.2	10.4	9.0	7.9	7.2	7.0	3.64
LX-12 80	321	200	152	116	89	68	55	30.8	21.5	16.5	13.9	11.9	10.2	9.0	8.3	8.0	4.16
LX-12 100	401	250	190	145	111	85	68	38.5	26.9	20.7	17.4	14.9	12.8	11.3	10.3	10.0	5.2
LX-12 120	481	300	228	174	133	102	82	46.2	32.3	24.8	20.8	17.9	15.4	13.5	12.4	12.0	6.2
LX-12 150	601	375	285	217	167	128	102	58	40.4	31.0	26.0	22.3	19.2	16.9	15.5	15.0	7.8
LX-6 115	461	288	218	166	128	98	78	44.2	31.0	23.8	20.0	17.1	14.7	13.0	11.9	11.5	6.0
LX-6 136	545	340	258	197	151	116	93	52	36.6	28.1	23.6	20.2	17.4	15.3	14.0	13.6	7.1

Constant Current Performance at 25ºC

End Voltage 1.85 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	48.1	30.0	22.8	17.4	13.3	9.9	7.9	4.46	3.12	2.40	2.02	1.73	1.49	1.31	1.20	1.16	0.62
LX-12 16	59	36.8	27.9	21.3	16.3	12.1	9.7	5.5	3.83	2.94	2.47	2.11	1.82	1.60	1.47	1.43	0.76
LX-12 20	74	46.0	34.9	26.6	20.4	15.1	12.1	6.8	4.78	3.68	3.09	2.64	2.28	2.01	1.84	1.78	0.95
LX-12 24	88	55	41.9	31.9	24.5	18.2	14.5	8.2	5.7	4.41	3.71	3.17	2.73	2.41	2.20	2.14	1.14
LX-12 25	92	58	43.7	33.3	25.6	19.0	15.2	8.6	6.0	4.61	3.87	3.31	2.85	2.51	2.30	2.23	1.19
LX-12 30	110	69	52	39.8	30.5	22.6	18.1	10.2	7.2	5.5	4.62	3.95	3.41	3.00	2.74	2.66	1.42
LX-12 37	136	85	64	49.0	37.6	27.9	22.3	12.6	8.8	6.8	5.7	4.87	4.20	3.69	3.38	3.28	1.75
LX-12 40	147	92	70	53	40.9	30.3	24.2	13.7	9.6	7.4	6.2	5.3	4.56	4.01	3.67	3.57	1.90
LX-12 50	184	115	87	66	51	37.8	30.2	17.1	11.9	9.2	7.7	6.6	5.7	5.00	4.58	4.45	2.37
LX-12 70	258	161	122	93	71	53	42.3	23.9	16.7	12.8	10.8	9.2	8.0	7.0	6.4	6.2	3.32
LX-12 80	294	183	139	106	81	60	48.3	27.3	19.1	14.7	12.3	10.5	9.1	8.0	7.3	7.1	3.79
LX-12 100	368	229	174	133	102	76	60	34.1	23.9	18.3	15.4	13.2	11.4	10.0	9.2	8.9	4.74
LX-12 120	442	275	209	159	122	91	73	41.0	28.7	22.0	18.5	15.8	13.6	12.0	11.0	10.7	5.7
LX-12 150	552	344	261	199	153	113	91	51	35.8	27.5	23.1	19.8	17.1	15.0	13.7	13.3	7.1
LX-6 115	423	264	200	153	117	87	69	39.2	27.4	21.1	17.7	15.2	13.1	11.5	10.5	10.2	5.5
LX-6 136	501	312	237	181	139	103	82	46.4	32.5	25.0	21.0	17.9	15.5	13.6	12.5	12.1	6.5

End Voltage 1.90 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	42.7	26.6	20.2	15.4	11.8	8.8	7.0	3.96	2.77	2.13	1.79	1.53	1.32	1.16	1.06	1.03	0.55
LX-12 16	53	32.9	25.0	19.0	14.6	10.8	8.7	4.90	3.42	2.63	2.21	1.89	1.63	1.44	1.31	1.28	0.68
LX-12 20	66	41.1	31.2	23.8	18.3	13.6	10.8	6.1	4.28	3.29	2.76	2.37	2.04	1.79	1.64	1.60	0.85
LX-12 24	79	49.4	37.5	28.6	21.9	16.3	13.0	7.3	5.1	3.95	3.32	2.84	2.45	2.15	1.97	1.91	1.02
LX-12 25	82	51	39.0	29.7	22.8	16.9	13.5	7.6	5.3	4.10	3.45	2.95	2.54	2.24	2.05	1.99	1.06
LX-12 30	99	62	47.0	35.9	27.5	20.4	16.3	9.2	6.4	4.95	4.16	3.56	3.07	2.70	2.47	2.40	1.28
LX-12 37	122	76	58	44.0	33.8	25.0	20.0	11.3	7.9	6.1	5.10	4.37	3.77	3.31	3.03	2.95	1.57
LX-12 40	132	82	62	47.6	36.6	27.1	21.7	12.2	8.6	6.6	5.5	4.73	4.08	3.59	3.28	3.19	1.70
LX-12 50	165	103	78	60	45.8	34.0	27.2	15.3	10.7	8.2	6.9	5.9	5.1	4.50	4.12	4.00	2.13
LX-12 70	231	144	110	83	64	47.5	38.0	21.5	15.0	11.5	9.7	8.3	7.1	6.3	5.8	5.6	2.98
LX-12 80	264	165	125	95	73	54	43.4	24.5	17.1	13.2	11.1	9.5	8.2	7.2	6.6	6.4	3.40
LX-12 100	330	206	156	119	91	68	54	30.6	21.4	16.4	13.8	11.8	10.2	9.0	8.2	8.0	4.25
LX-12 120	396	247	187	143	110	81	65	36.7	25.7	19.7	16.6	14.2	12.2	10.8	9.9	9.6	5.1
LX-12 150	495	309	234	179	137	102	81	45.9	32.1	24.7	20.7	17.8	15.3	13.5	12.3	12.0	6.4
LX-6 115	380	237	180	137	105	78	62	35.2	24.6	18.9	15.9	13.6	11.7	10.3	9.4	9.2	4.89
LX-6 136	449	280	212	162	124	92	74	41.6	29.1	22.4	18.8	16.1	13.9	12.2	11.2	10.8	5.8

Constant Power Performance at 25ºC

End Voltage 1.60 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	106	68	52	40.1	31.0	23.1	18.7	10.6	7.5	5.8	4.85	4.16	3.59	3.16	2.90	2.82	1.48
LX-12 16	131	84	64	49.4	38.2	28.5	23.0	13.1	9.2	7.1	6.0	5.1	4.42	3.90	3.57	3.47	1.82
LX-12 20	163	104	80	62	47.6	35.5	28.7	16.4	11.5	8.8	7.4	6.4	5.5	4.86	4.46	4.33	2.27
LX-12 24	196	125	96	74	57	42.6	34.4	19.6	13.7	10.6	8.9	7.6	6.6	5.8	5.3	5.2	2.72
LX-12 25	204	130	100	77	59	44.3	35.7	20.4	14.3	11.0	9.3	8.0	6.9	6.1	5.5	5.4	2.82
LX-12 30	245	156	120	92	71	53	43.0	24.5	17.2	13.3	11.2	9.6	8.3	7.3	6.7	6.5	3.40
LX-12 37	302	193	148	114	88	66	53	30.2	21.2	16.3	13.8	11.8	10.2	9.0	8.2	8.0	4.19
LX-12 38	327	209	160	123	95	71	57	32.7	22.9	17.7	14.9	12.8	11.0	9.7	8.9	8.7	4.54
LX-12 50	409	261	200	154	119	89	72	40.9	28.7	22.1	18.6	16.0	13.8	12.2	11.1	10.8	5.7
LX-12 70	572	365	280	215	167	124	100	57	40.1	30.9	26.1	22.3	19.3	17.0	15.6	15.1	7.9
LX-12 80	652	416	319	246	190	142	114	65	45.8	35.3	29.7	25.5	22.0	19.4	17.8	17.3	9.0
LX-12 100	816	521	399	307	238	177	143	82	57	44.1	37.2	31.9	27.5	24.3	22.2	21.6	11.3
LX-12 120	979	625	479	369	285	213	172	98	69	53	44.6	38.2	33.0	29.1	26.7	25.9	13.6
LX-12 150	1224	781	599	461	357	266	215	122	86	66	56	47.8	41.3	36.4	33.4	32.4	17.0
LX-6 115	939	599	460	354	274	204	165	94	66	50.8	42.8	36.7	31.7	27.9	25.6	24.9	13.0
LX-6 136	1110	709	543	418	324	241	195	111	78	60	50.6	43.4	37.5	33.0	30.3	29.4	15.4

End Voltage 1.63 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	105	67	52	39.7	30.7	22.9	18.5	10.5	7.4	5.7	4.80	4.12	3.56	3.13	2.87	2.79	1.46
LX-12 16	130	83	64	48.9	37.8	28.2	22.8	13.0	9.1	7.0	5.9	5.07	4.38	3.86	3.54	3.44	1.80
LX-12 20	162	103	79	61	47.2	35.2	28.4	16.2	11.4	8.8	7.4	6.3	5.5	4.81	4.41	4.29	2.25
LX-12 24	194	124	95	73	57	42.2	34.1	19.4	13.6	10.5	8.8	7.6	6.5	5.8	5.3	5.1	2.69
LX-12 25	202	129	99	76	59	43.8	35.4	20.2	14.1	10.9	9.2	7.9	6.8	6.0	5.5	5.3	2.80
LX-12 30	243	155	119	91	71	53	42.6	24.3	17.0	13.1	11.1	9.5	8.2	7.2	6.6	6.4	3.37
LX-12 37	299	191	147	113	87	65	53	30.0	21.0	16.2	13.6	11.7	10.1	8.9	8.2	7.9	4.15
LX-12 38	324	207	159	122	94	70	57	32.4	22.7	17.5	14.7	12.6	10.9	9.6	8.8	8.6	4.49
LX-12 50	405	258	198	152	118	88	71	40.5	28.4	21.9	18.4	15.8	13.7	12.0	11.0	10.7	5.6
LX-12 70	567	362	277	213	165	123	99	57	39.8	30.6	25.8	22.1	19.1	16.8	15.4	15.0	7.9
LX-12 80	646	412	316	243	188	140	113	65	45.3	34.9	29.4	25.2	21.8	19.2	17.6	17.1	9.0
LX-12 100	808	516	396	304	236	176	142	81	57	43.7	36.8	31.6	27.3	24.0	22.0	21.4	11.2
LX-12 120	970	619	475	365	283	211	170	97	68	52	44.2	37.9	32.7	28.8	26.4	25.7	13.5
LX-12 150	1213	774	594	457	353	264	213	121	85	66	55	47.4	40.9	36.1	33.1	32.1	16.8
LX-6 115	930	594	455	350	271	202	163	93	65	50.3	42.4	36.3	31.4	27.7	25.4	24.6	12.9
LX-6 136	1100	702	538	414	321	239	193	110	77	59	50.1	43.0	37.1	32.7	30.0	29.1	15.3

End Voltage 1.67 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	104	67	51	39.3	30.4	22.7	18.3	10.4	7.3	5.6	4.75	4.08	3.52	3.10	2.85	2.76	1.45
LX-12 16	129	82	63	48.4	37.5	28.0	22.6	12.9	9.0	7.0	5.9	5.02	4.34	3.82	3.51	3.41	1.78
LX-12 20	160	102	78	60	46.7	34.9	28.1	16.0	11.3	8.7	7.3	6.3	5.4	4.77	4.37	4.25	2.23
LX-12 24	192	123	94	72	56	41.8	33.7	19.2	13.5	10.4	8.8	7.5	6.5	5.7	5.2	5.09	2.67
LX-12 25	200	127	98	75	58	43.4	35.1	20.0	14.0	10.8	9.1	7.8	6.7	5.9	5.4	5.3	2.77
LX-12 30	241	154	118	91	70	52	42.2	24.1	16.9	13.0	11.0	9.4	8.1	7.2	6.6	6.4	3.34
LX-12 37	297	189	145	112	86	64	52	29.7	20.8	16.0	13.5	11.6	10.0	8.8	8.1	7.9	4.11
LX-12 38	321	205	157	121	93	70	56	32.1	22.5	17.3	14.6	12.5	10.8	9.5	8.7	8.5	4.45
LX-12 50	401	256	196	151	117	87	70	40.1	28.1	21.7	18.3	15.7	13.5	11.9	10.9	10.6	5.6
LX-12 70	561	358	275	211	164	122	99	56	39.4	30.3	25.6	21.9	18.9	16.7	15.3	14.9	7.8
LX-12 80	640	408	313	241	187	139	112	64	44.9	34.6	29.1	25.0	21.6	19.0	17.4	16.9	8.9
LX-12 100	800	511	392	301	233	174	140	80	56	43.3	36.5	31.3	27.0	23.8	21.8	21.2	11.1
LX-12 120	961	613	470	362	280	209	169	96	67	52	43.8	37.5	32.4	28.6	26.2	25.4	13.3
LX-12 150	1201	767	588	452	350	261	211	120	84	65	55	46.9	40.5	35.7	32.7	31.8	16.7
LX-6 115	921	588	451	347	269	200	162	92	65	49.8	42.0	36.0	31.1	27.4	25.1	24.4	12.8
LX-6 136	1089	695	533	410	317	237	191	109	76	59	49.6	42.6	36.7	32.4	29.7	28.8	15.1

Constant Power Performance at 25ºC

End Voltage 1.70 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	102	65	50.1	38.6	29.8	22.3	18.0	10.2	7.2	5.5	4.66	4.00	3.45	3.04	2.79	2.71	1.42
LX-12 16	126	80	62	47.5	36.8	27.4	22.1	12.6	8.9	6.8	5.7	4.93	4.25	3.75	3.44	3.34	1.75
LX-12 20	157	100	77	59	45.8	34.2	27.6	15.7	11.0	8.5	7.2	6.1	5.3	4.68	4.29	4.16	2.18
LX-12 24	188	120	92	71	55	41.0	33.1	18.9	13.2	10.2	8.6	7.4	6.4	5.6	5.1	4.99	2.61
LX-12 25	196	125	96	74	57	42.6	34.4	19.6	13.7	10.6	8.9	7.7	6.6	5.8	5.3	5.2	2.72
LX-12 30	236	151	115	89	69	51	41.4	23.6	16.6	12.8	10.7	9.2	8.0	7.0	6.4	6.2	3.27
LX-12 37	291	186	142	110	85	63	51	29.1	20.4	15.7	13.2	11.4	9.8	8.6	7.9	7.7	4.04
LX-12 38	315	201	154	118	92	68	55	31.5	22.1	17.0	14.3	12.3	10.6	9.4	8.6	8.3	4.36
LX-12 50	393	251	192	148	115	85	69	39.3	27.6	21.3	17.9	15.4	13.3	11.7	10.7	10.4	5.5
LX-12 70	550	351	269	207	160	120	97	55	38.6	29.8	25.1	21.5	18.6	16.4	15.0	14.6	7.6
LX-12 80	628	401	307	236	183	136	110	63	44.0	33.9	28.6	24.5	21.2	18.7	17.1	16.6	8.7
LX-12 100	785	501	384	296	229	171	138	79	55	42.4	35.8	30.7	26.5	23.3	21.4	20.8	10.9
LX-12 120	942	601	461	355	275	205	165	94	66	51	42.9	36.8	31.8	28.0	25.7	24.9	13.1
LX-12 150	1178	752	577	444	343	256	207	118	83	64	54	46.0	39.7	35.0	32.1	31.2	16.3
LX-6 115	904	577	442	340	263	196	159	90	63	48.8	41.2	35.3	30.5	26.9	24.6	23.9	12.5
LX-6 136	1068	682	523	402	311	232	188	107	75	58	48.7	41.7	36.0	31.8	29.1	28.3	14.8

End Voltage 1.75 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	100	64	49.1	37.8	29.3	21.8	17.6	10.0	7.0	5.43	4.57	3.92	3.39	2.98	2.74	2.66	1.39
LX-12 16	124	79	61	46.6	36.0	26.9	21.7	12.4	8.7	6.7	5.6	4.83	4.17	3.68	3.37	3.27	1.72
LX-12 20	154	98	75	58	44.9	33.5	27.1	15.4	10.8	8.3	7.0	6.0	5.2	4.58	4.20	4.08	2.14
LX-12 24	185	118	90	70	54	40.2	32.4	18.5	13.0	10.0	8.4	7.2	6.2	5.5	5.04	4.89	2.56
LX-12 25	192	123	94	72	56	41.8	33.7	19.2	13.5	10.4	8.7	7.5	6.5	5.7	5.2	5.1	2.66
LX-12 30	231	148	113	87	67	50.3	40.6	23.1	16.2	12.5	10.5	9.0	7.8	6.9	6.3	6.1	3.21
LX-12 37	285	182	140	107	83	62	50.0	28.5	20.0	15.4	13.0	11.1	9.6	8.5	7.8	7.5	3.96
LX-12 38	308	197	151	116	90	67	54	30.9	21.6	16.7	14.0	12.0	10.4	9.2	8.4	8.2	4.28
LX-12 50	385	246	189	145	112	84	68	38.6	27.1	20.8	17.6	15.1	13.0	11.5	10.5	10.2	5.3
LX-12 70	540	344	264	203	157	117	95	54	37.9	29.2	24.6	21.1	18.2	16.0	14.7	14.3	7.5
LX-12 80	615	393	301	232	179	134	108	62	43.2	33.3	28.0	24.0	20.8	18.3	16.8	16.3	8.5
LX-12 100	770	491	377	290	224	167	135	77	54	41.6	35.1	30.1	26.0	22.9	21.0	20.4	10.7
LX-12 120	924	590	452	348	269	201	162	92	65	49.9	42.1	36.1	31.2	27.5	25.2	24.5	12.8
LX-12 150	1155	737	565	435	337	251	203	116	81	62	53	45.1	39.0	34.3	31.5	30.6	16.0
LX-6 115	886	565	434	334	258	193	156	89	62	47.9	40.4	34.6	29.9	26.3	24.2	23.5	12.3
LX-6 136	1047	668	513	395	305	228	184	105	73	57	47.7	40.9	35.3	31.1	28.6	27.7	14.5

End Voltage 1.80 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	95	61	46.7	35.9	27.8	20.7	16.7	9.5	6.7	5.2	4.34	3.72	3.22	2.84	2.60	2.52	1.32
LX-12 16	117	75	57	44.2	34.2	25.5	20.6	11.8	8.2	6.3	5.4	4.59	3.96	3.49	3.20	3.11	1.63
LX-12 20	146	93	72	55	42.7	31.9	25.7	14.7	10.3	7.9	6.7	5.7	4.94	4.36	3.99	3.88	2.03
LX-12 24	176	112	86	66	51	38.2	30.8	17.6	12.3	9.5	8.0	6.9	5.9	5.2	4.78	4.65	2.44
LX-12 25	182	116	89	69	53	39.7	32.0	18.3	12.8	9.9	8.3	7.1	6.2	5.4	4.97	4.83	2.53
LX-12 30	220	140	108	83	64	47.8	38.6	22.0	15.4	11.9	10.0	8.6	7.4	6.5	6.0	5.8	3.05
LX-12 37	271	173	133	102	79	59	47.5	27.1	19.0	14.6	12.3	10.6	9.1	8.1	7.4	7.2	3.76
LX-12 38	293	187	143	110	85	64	51.4	29.3	20.6	15.8	13.3	11.4	9.9	8.7	8.0	7.8	4.06
LX-12 50	366	234	179	138	107	80	64	36.6	25.7	19.8	16.7	14.3	12.4	10.9	10.0	9.7	5.08
LX-12 70	513	327	251	193	149	111	90	51	36.0	27.7	23.4	20.0	17.3	15.2	14.0	13.6	7.1
LX-12 80	585	373	286	220	170	127	103	58	41.0	31.6	26.6	22.8	19.7	17.4	15.9	15.5	8.1
LX-12 100	731	467	358	275	213	159	128	73	51	39.5	33.3	28.6	24.7	21.7	19.9	19.4	10.1
LX-12 120	878	560	430	331	256	191	154	88	62	47.4	40.0	34.3	29.6	26.1	23.9	23.2	12.2
LX-12 150	1097	700	537	413	320	239	193	110	77	59	50.0	42.9	37.0	32.6	29.9	29.1	15.2
LX-6 115	842	537	412	317	245	183	148	84	59	45.5	38.3	32.9	28.4	25.0	22.9	22.3	11.7
LX-6 136	995	635	487	375	290	216	175	100	70	54	45.3	38.9	33.6	29.6	27.1	26.3	13.8

Constant Power Performance at 25ºC

End Voltage 1.85 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	87	56	42.7	32.9	25.5	19.0	15.3	8.7	6.1	4.72	3.98	3.41	2.95	2.60	2.38	2.31	1.21
LX-12 16	108	69	53	40.5	31.4	23.4	18.9	10.8	7.5	5.8	4.90	4.20	3.63	3.20	2.93	2.85	1.49
LX-12 20	134	86	66	50.5	39.1	29.2	23.5	13.4	9.4	7.3	6.1	5.2	4.53	3.99	3.66	3.55	1.86
LX-12 24	161	103	79	61	46.8	34.9	28.2	16.1	11.3	8.7	7.3	6.3	5.4	4.78	4.38	4.26	2.23
LX-12 25	167	107	82	63	48.7	36.3	29.3	16.7	11.7	9.0	7.6	6.5	5.6	4.97	4.55	4.42	2.32
LX-12 30	201	128	98	76	59	43.8	35.3	20.1	14.1	10.9	9.2	7.9	6.8	6.0	5.5	5.3	2.79
LX-12 37	248	158	121	93	72	54	43.5	24.8	17.4	13.4	11.3	9.7	8.4	7.4	6.8	6.6	3.44
LX-12 38	268	171	131	101	78	58	47.1	26.8	18.8	14.5	12.2	10.5	9.1	8.0	7.3	7.1	3.72
LX-12 50	335	214	164	126	98	73	59	33.6	23.5	18.1	15.3	13.1	11.3	10.0	9.1	8.9	4.65
LX-12 70	470	300	230	177	137	102	82	47.0	32.9	25.4	21.4	18.3	15.8	14.0	12.8	12.4	6.5
LX-12 80	535	342	262	202	156	116	94	54	37.6	28.9	24.4	20.9	18.1	15.9	14.6	14.2	7.4
LX-12 100	670	427	328	252	195	146	118	67	47.0	36.2	30.5	26.2	22.6	19.9	18.3	17.7	9.3
LX-12 120	804	513	393	303	234	175	141	80	56	43.4	36.6	31.4	27.1	23.9	21.9	21.3	11.2
LX-12 150	1005	641	492	379	293	218	176	101	71	54	45.8	39.3	33.9	29.9	27.4	26.6	13.9
LX-6 115	771	492	377	290	225	168	135	77	54	41.7	35.1	30.1	26.0	22.9	21.0	20.4	10.7
LX-6 136	911	582	446	343	266	198	160	91	64	49.3	41.5	35.6	30.7	27.1	24.8	24.1	12.6

End Voltage 1.90 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	78	50.0	38.3	29.5	22.8	17.0	13.7	7.8	5.49	4.23	3.57	3.06	2.64	2.33	2.13	2.07	1.09
LX-12 16	96	62	47.2	36.3	28.1	21.0	16.9	9.6	6.8	5.2	4.39	3.77	3.25	2.87	2.63	2.55	1.34
LX-12 20	120	77	59	45.3	35.1	26.2	21.1	12.0	8.4	6.5	5.5	4.70	4.06	3.58	3.28	3.18	1.67
LX-12 24	144	92	71	54	42.0	31.3	25.3	14.4	10.1	7.8	6.6	5.6	4.86	4.28	3.93	3.82	2.00
LX-12 25	150	96	73	56	43.7	32.6	26.3	15.0	10.5	8.1	6.8	5.9	5.05	4.45	4.08	3.97	2.08
LX-12 30	180	115	88	68	53	39.2	31.7	18.1	12.7	9.8	8.2	7.0	6.1	5.4	4.92	4.78	2.50
LX-12 37	222	142	109	84	65	48.4	39.0	22.3	15.6	12.0	10.1	8.7	7.5	6.6	6.1	5.9	3.09
LX-12 38	241	154	118	91	70	52.3	42.2	24.1	16.9	13.0	11.0	9.4	8.1	7.2	6.6	6.4	3.34
LX-12 50	301	192	147	113	88	65	53	30.1	21.1	16.3	13.7	11.7	10.1	8.9	8.2	8.0	4.17
LX-12 70	421	269	206	159	123	92	74	42.1	29.5	22.8	19.2	16.4	14.2	12.5	11.5	11.1	5.8
LX-12 80	480	306	235	181	140	104	84	48.0	33.7	25.9	21.9	18.7	16.2	14.3	13.1	12.7	6.7
LX-12 100	600	383	294	226	175	131	105	60	42.1	32.4	27.3	23.4	20.2	17.8	16.4	15.9	8.3
LX-12 120	721	460	353	271	210	157	126	72	50.6	38.9	32.8	28.1	24.3	21.4	19.6	19.1	10.0
LX-12 150	901	575	441	339	263	196	158	90	63	48.7	41.0	35.2	30.4	26.8	24.6	23.9	12.5
LX-6 115	691	441	338	260	201	150	121	69	48.5	37.4	31.5	27.0	23.3	20.5	18.8	18.3	9.6
LX-6 136	817	521	400	308	238	178	143	82	57	44.2	37.2	31.9	27.6	24.3	22.3	21.6	11.3

Battery Sizing and Selection

Sizing and selection of a battery is application specific. Certain correction factors also have to be applied before arriving at the final battery capacity.

Correction factors

1) K factor (designated C_K) See Table 2
   It is the ratio of 'Rated Capacity' to 'Amperes' that can be supplied for the required 't' time.

2) Temperature correction factor (designated C_{TC}) See Table 3
   It is the ratio of the 'Rated Capacity' to the Capacity obtainable at t°C.

3) Aging factor (designated C_{AF})
   Normally taken to be 1.25 (1/0.8) considering 80% as the end of life criterion.

4) Design margin (designated C_{DM})
   A nominal 10% cushion is taken as standard over-sizing to take care of design errors in the load specifications. This may also be specified by the user.

5) Over load factor (designated C_{OL})
   Reserve capacity that may be installed to take care of future additional loads. Normally 10% is considered. This again depends on customer's requirement.

A) Battery Sizing for UPS Applications

UPS loads have constant power requirements. The procedure for sizing batteries for constant power loads is given below:

Example

01. Power rating	: 2 KVA
02. Power factor	: 0.8 (not required if power rating is given in KW)
03. Maximum voltage	: 130 V
04. Minimum voltage	: 90 V
05. Inverter efficiency	: 85%
06. End cell voltage	: 1.75 V (10.5 V per 12 V monobloc)
07. Minimum operating temperature	: 25°C
08. Back-up time	: 30 minutes
09. Ageing factor	: 1.25
10. Design margin	: 10%
11. Overload factor	: 10%
12. Charging voltage	: 108 V

Calculations

Step 1 Calculate power output of UPS (W_{UPS})
(not required if power output is already given in KW)

W_{UPS} = KVA x Power factor = 2 x 0.8 = 1.6 KW

Step 2 Calculate power required from battery

W_{bty} = [UPS output wattage (in KW) x 1000] / Inverter efficiency
= (1.6 x 1000) / 0.85 = 1882.4 W

Step 3 Calculate number of blocs required

Minimum number required = Minimum voltage / End of discharge voltage
= 90 / 10.5 = 8.57 blocs

Maximum number required = Maximum voltage / Float charging voltage
= 130 / 13.5 = 9.63 blocs

Number of blocs selected = 9 of 12V each

Step 4 Calculate power required per bloc

W_{bloc} = Total watts / number of blocs
= 1882.4 / 9 = 209.2 W

Step 5 Apply Temperature correction factor

Temperature correction factor for 25ºC (C_T) = 1.0
Wattage required = 209.2 x 1.0 = 209.2 W

Step 6 Apply Ageing factor C_{AF}

Wattage required = 209.2 x 1.25 = 261.5 W

Step 7 Apply Design factor C_{DF}

Wattage required = 261.5 x 1.1 = 287.65 W

Step 8 Apply Overload factor C_{OL}

Wattage required = 287.65 x 1.1 = 316.42 W per 12V bloc or 52.7 W per cell

Step 9 Select monobloc type

From the monobloc range, pick the model which gives the required watts for the duration and end voltage specified.

Monobloc Type selected LX- 12 24

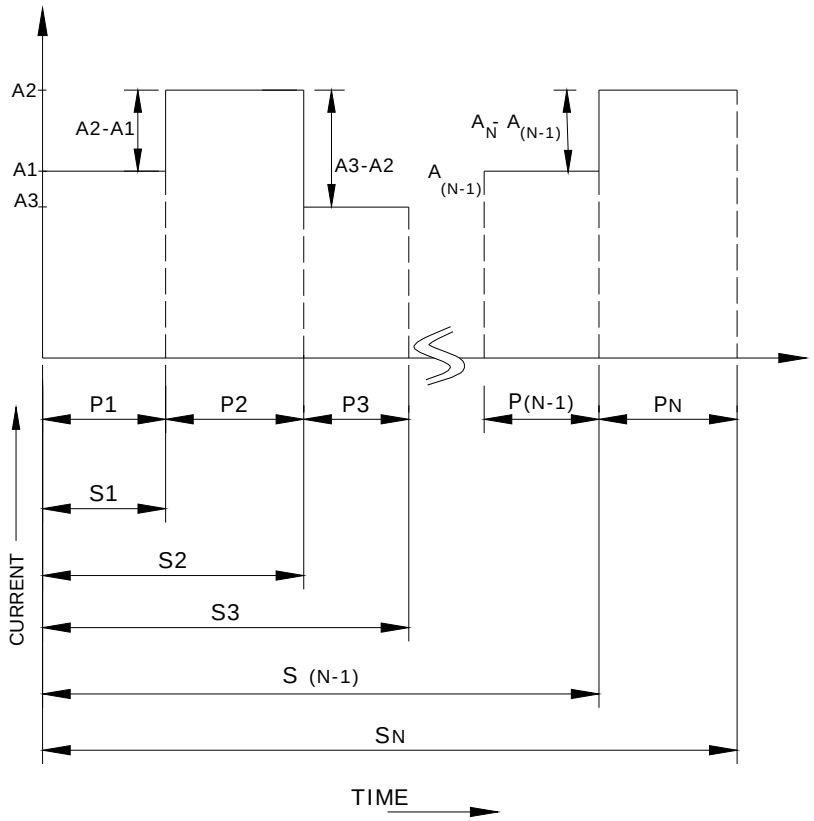
C) Battery Sizing for Duty Cycle Applications

Individual DC loads supplied by the battery during the duty cycle may be classified as under:

1) Continuous loads
2) Non continuous loads (> 1 minute)
3) Non continuous momentary loads (< 1 minute)

The IEEE Std 485-1997 gives the recommended practice for sizing batteries for stationary applications according to a specified duty cycle.
The Generalized duty cycle can be drawn as follows:

Figure 1



The maximum capacity (max Fs) calculated determines the uncorrected cell size that can be expressed by the following general equation.

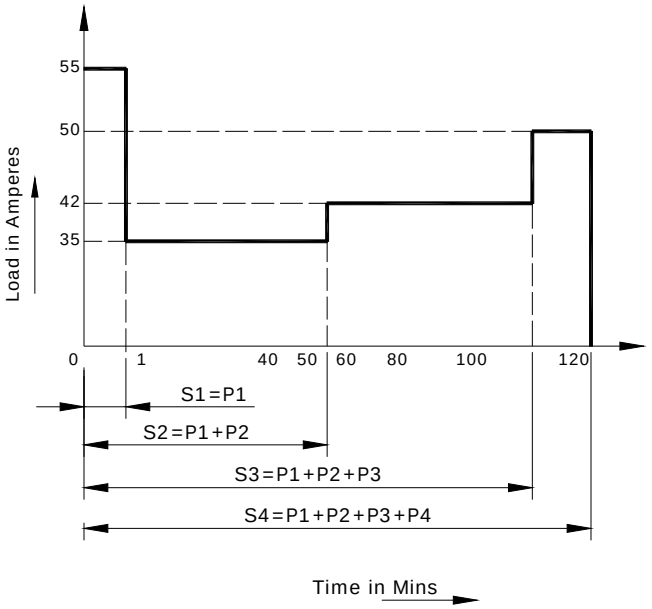
$$F = \max_{S=1}^{S=N} Fs$$

Where

S	is the section of the duty cycle being analyzed. [Section S contains the first S periods of the duty cycle (e.g. section S5 contains periods S1 through S5). See Figure 1 for a Graphical representation of "section".
N	is the number of periods in the duty cycles;
P	is the period being analyzed;
Ap	are the amperes required for period P;
T	is the time in minutes from the beginning of duty cycle through the end of section S;
M	is the time of each period in minutes

If the current for period P+1 is greater than the current for period P, then section S=P+1 will require a larger cell than section S=P. Consequently, the calculations for section S = P can be omitted.

Example
Selection of a battery for a regime having the following load profile for a voltage of 12V, operating temperature of 25°C and considering a Design Margin of 10%



Load Name	Load in amps	Time in Mins (M)
Load A1	55	0.185
Load A2	35	59
Load A3	42	55
Load A4	50	5

Note:
1. Any start period of less than 1 minute duration is considered for 1 minute.
2. In any section N, if the current for the 'N+1' period is higher than the current of the period 'N' then the section 'N' may be skipped as the next section 'N+1' will be of higher size.
3. Number of monoblocs = Total system Voltage / Nominal voltage of a monobloc

Calculations

Step 1 Fill the Load 'A' and period 'M' values in columns 2 & 4
Step 2 Fill the changes in the load as the difference between the present load and previous load with sign (positive or negative) in column 3
Step 3 Fill the duration 'T' for each period from the beginning (T=0) to the end of each section in column 5
Step 4 Enter the k-factor value, for each duration 'T' in column 6. Refer Table 2 for k-factors
Step 5 The capacity for each period 'P' is calculated by multiplying column 3 and column 6 and entered in column 7 with sign (positive or negative)
Step 6 The sum of capacities for all periods in every section is taken as the size of the section.
Step 7 The maximum value of all the sections noted as above plus the value in random load section, if any is taken as the uncorrected size.
Step 8 Apply Temperature Correction Factor (C_{TC})
Step 9 Apply Ageing Factor (C_{AF})
Step 10 Apply Design Margin (C_{DM})

Worksheet

(1) Period (Nos)	(2) Load (amps)	(3) Change in Load (amps)	(4) Duration of period (mins)	(5) Time to end of section (mins)	(6) Cap at T min rate K factor	(7) Reqd sec size 3*6(Ah)
Section 1 – First period only if A2 > A1, go to section 2						
1	A1=55	A1-0=55	M1=1	T=M1=1	0.149	8.19
					Sec 1 Total	
Section –2 First two periods only – if A3 > A2 go to section –3						
1	A1=	A1-0=	M1=	T=M1+M2=		
2	A2=	A2-A1=	M2=	T=M2=		
					Sec 2 Total	
Section-3 First 3 periods only If A4 > A3 go to section 4						
1	A1=	A1-0=	M1=	T=M1+M3		
2	A2=	A2-A1=	M2=	T=M2+M3		
3	A3=	A3-A2=	M3=	T=M3=		
					Sec 3 Total	
Section-4 First 4 periods only, if A3 >A4, go to section 5						
1	A1=55	A1-0=55	M1=1	T=M1+M2+M3+M4= 120 mins	2.55	140.25
2	A2=35	A2-A1= -20	M2=59	T=M2+M3+M4=119 mins	2.55	-51
3	A3=42	A3-A2= 7	M3=55	T=M3+M4=60 mins	1.439	10.07
4.	A4=50	A4-A3=8	M4=5	T=M4=5 mins	0.236	1.888
					Sec 4 Total	101.20
Applying temperature correction factor Capacity required = 101.9 x 1.0 = 101.2 Ah						
Applying Ageing factor Capacity required = 101.2 x 1.25 = 126.5 Ah						
Applying Design Margin Capacity required = 126.5 x 1.1 = 139.15 Ah						
Monobloc Type Selected LX-12 150						

K - Factor (C_k)

Table 2

Time	End Cell Voltage							
	1.50	1.60	1.67	1.70	1.75	1.80	1.85	1.90
1 minute	0.136	0.140	0.143	0.146	0.149	0.157	0.171	0.191
2 minutes	0.145	0.149	0.152	0.155	0.158	0.166	0.181	0.202
5 minutes	0.220	0.223	0.227	0.232	0.236	0.250	0.272	0.303
10 minutes	0.353	0.358	0.365	0.372	0.379	0.400	0.436	0.486
15 minutes	0.464	0.471	0.480	0.489	0.499	0.527	0.574	0.640
20 minutes	0.609	0.618	0.630	0.642	0.655	0.691	0.753	0.840
30 minutes	0.794	0.805	0.821	0.837	0.853	0.901	0.981	1.094
45 minutes	1.071	1.086	1.107	1.128	1.151	1.173	1.323	1.475
1 hour	1.339	1.358	1.384	1.411	1.439	1.468	1.654	1.845
2 hours	2.37	2.40	2.45	2.50	2.55	2.60	2.93	3.27
3 hours	3.39	3.44	3.50	3.57	3.64	3.71	4.19	4.67
4 hours	4.41	4.47	4.56	4.65	4.74	4.84	5.45	6.08
5 hours	5.25	5.33	5.43	5.53	5.64	5.76	6.49	7.24
6 hours	6.13	6.22	6.34	6.46	6.59	6.72	7.58	8.45
7 hours	7.11	7.22	7.35	7.50	7.65	7.81	8.79	9.81
8 hours	8.09	8.20	8.36	8.52	8.70	8.87	9.99	11.14
9 hours	8.83	8.96	9.13	9.31	9.50	9.70	10.91	12.17
10 hours	9.10	9.22	9.40	9.59	9.81	10.00	11.24	12.54
20 hours	17.07	17.31	17.64	18.00	18.89	19.3	21.1	23.5
24 hours					22.2			
48 hours					43.1			
72 hours					62.4			
96 hours					83.1			
120 hours					98.6			

Temperature correction Factor (C_{TC})

Table3

Temp.	Discharge Duration in minutes															
(°C)	5	10	15	20	30	45	60	120	180	240	300	360	420	480	540	600
- 30	3.644	3.403	3.283	3.205	3.107	3.021	2.967	2.854	2.802	2.769	2.749	2.738	2.726	2.710	2.704	2.698
- 25	2.869	2.680	2.585	2.524	2.446	2.379	2.337	2.248	2.207	2.180	2.165	2.156	2.147	2.135	2.130	2.125
- 20	2.416	2.257	2.177	2.126	2.060	2.004	1.968	1.893	1.858	1.836	1.823	1.816	1.808	1.797	1.793	1.789
- 15	2.186	2.042	1.898	1.923	1.864	1.813	1.780	1.712	1.681	1.661	1.649	1.643	1.636	1.626	1.622	1.619
- 10	1.882	1.757	1.695	1.655	1.604	1.560	1.532	1.474	1.447	1.430	1.420	1.414	1.408	1.400	1.396	1.393
- 5	1.676	1.565	1.522	1.474	1.429	1.389	1.365	1.312	1.289	1.273	1.264	1.259	1.254	1.246	1.244	1.241
0	1.572	1.468	1.404	1.383	1.340	1.304	1.280	1.232	1.209	1.195	1.186	1.181	1.176	1.170	1.167	1.164
5	1.418	1.340	1.302	1.277	1.245	1.217	1.199	1.164	1.143	1.136	1.130	1.127	1.123	1.119	1.117	1.115
10	1.287	1.233	1.206	1.188	1.166	1.145	1.134	1.107	1.096	1.089	1.085	1.083	1.080	1.078	1.076	1.075
15	1.176	1.143	1.125	1.114	1.100	1.087	1.079	1.064	1.056	1.052	1.049	1.048	1.047	1.045	1.044	1.044
20	1.082	1.066	1.057	1.052	1.045	1.040	1.035	1.028	1.025	1.022	1.021	1.021	1.020	1.019	1.019	1.018
25	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
30	0.929	0.943	0.951	0.956	0.962	0.968	0.972	0.978	0.981	0.983	0.984	0.985	0.985	0.986	0.986	0.986
35	0.867	0.895	0.910	0.919	0.931	0.943	0.949	0.962	0.969	0.972	0.974	0.974	0.975	0.977	0.977	0.977
40	0.813	0.851	0.874	0.888	0.906	0.922	0.932	0.951	0.961	0.965	0.967	0.968	0.969	0.971	0.971	0.971

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